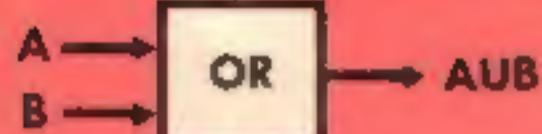




# Technical Review

VOLUME 20 NO. 2

APRIL 1988



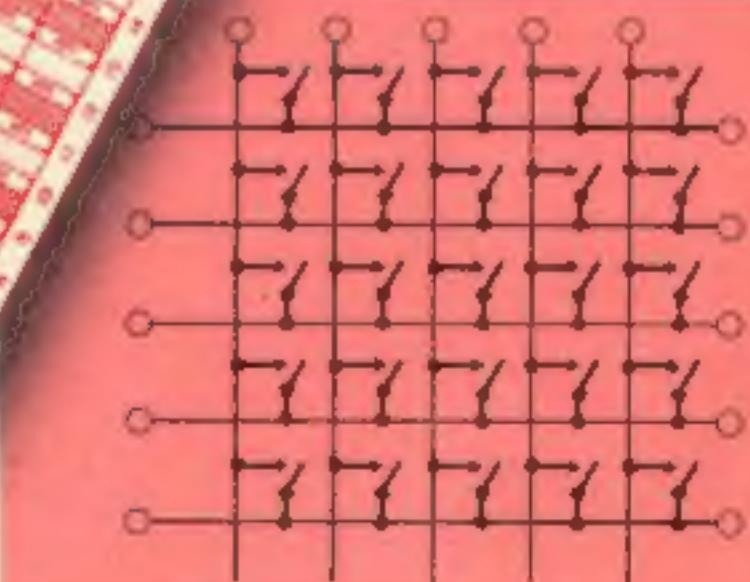
$$\binom{n}{k} (1-R)^k R^{n-k}$$



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CIRCUIT  
SWITCHING  
NETWORK  
Page 70



**PUNCHED CARD  
TRANSMITTER  
Part III**



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technical publication*

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The purpose of the TECHNICAL REVIEW is to present technological advances and their applications to communications.

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**in**  
**Communications Systems**

**New**  
**Punched Card Transmitter**  
**Part III**

**Transistorized**  
**Data Network**  
**Repeater**

**CSN for ARS**

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**Cover:** The mark-sense data card designed by Western Union for the punched card transmitter shows pencil-marked information in addition to the punched-hole information.

# *reliability in communications systems*

—Bernard Rider

Modern computer-controlled message switching systems exhibit different reliability characteristics from those associated with the automatic and semiautomatic electromechanical relay systems of the recent past. In the electromechanical systems, a component failure (which occurs relatively frequently) causes only a graceful degradation of service, because the system's operational functions are distributed over many independent components. A failure in one of these components affects only one circuit and therefore produces a slightly reduced overall grade of service for the system.

Figure 1 illustrates a switching system in which a single component failure causes only one circuit to fail. This one failure does not otherwise affect overall system operation. However, in computer-controlled systems, component failures although infrequent, can cause serious service lapses. This is due to the fact that the computer systems use relatively few interdependent major components. A failure in a vital computer component can cause a catastrophic system failure as shown in Figure 2. Many communications systems can tolerate service lapses only if they are infrequent and brief. However, there are vital military and civil networks for which any service interruption is intolerable. For computer operation of these systems, special consideration must be given to the employment of redundancy to achieve very high reliability.

While it is theoretically impossible to achieve 100% reliability in any system, a very high reliability can be assured through proper design.

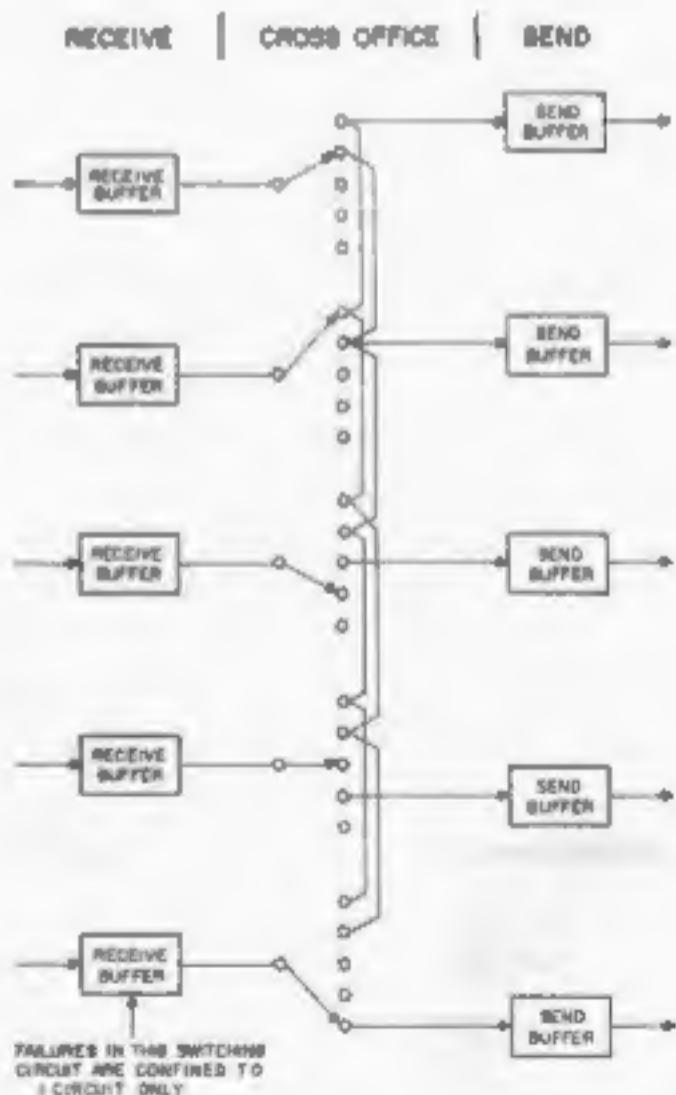


Figure 1. Electromechanical Switching System

## Redundancy Technique

As an example of how redundancy can improve reliability, let us consider a component, A, which is 99% reliable. That is, it has a 99% probability of operating properly and a 1% probability of failing. Suppose that a second component, B, is provided which can perform the same function and has the same reliability. A and B are connected so that either component, or both, can perform the desired function. The reliability of the combination is 99.99%. This can be derived mathematically, as follows:

Let A = the condition that A is operable

B = the condition that B is operable

The Boolean algebraic expression for system operation is

$A \cup B$  (meaning A or B or both).

Let the reliability of A be given by  $R_A$  and the reliability of B by  $R_B$ . The system reliability is then given by:

$$R_{sys} = R_A + R_B - R_A R_B \quad (1)$$

Since both components are assumed identical,

$$R_A = R_B = R \quad (2)$$

Using (2) in (1)

$$R_{sys} = R(2 - R) \quad (3)$$

R is always less than unity, usually between 0.9 and 1.0.

For ease in computation, let

$$R = 1 - \delta \text{ where } \delta \ll 1 \quad (4)$$

Using (4) in (3)

$$R = 1 - \delta^2 \quad (5)$$

For the example cited,  $R = 0.99$  and therefore  $\delta = 0.01$ . In accordance with (5)

$$R_{sys} = 1 - 0.01^2 = 0.9999 \quad (6)$$

## A Redundant Computer Message Switch

The design of reliable computer controlled message switches must utilize the concept of redundancy. Where single units of a given kind are required, two identical units must be installed, with provisions for switching from one to the other in the event of a failure. Where more than one unit of a given kind is required, the number of redundant (back up) units to be installed can be calculated to maintain reliability at a given level.

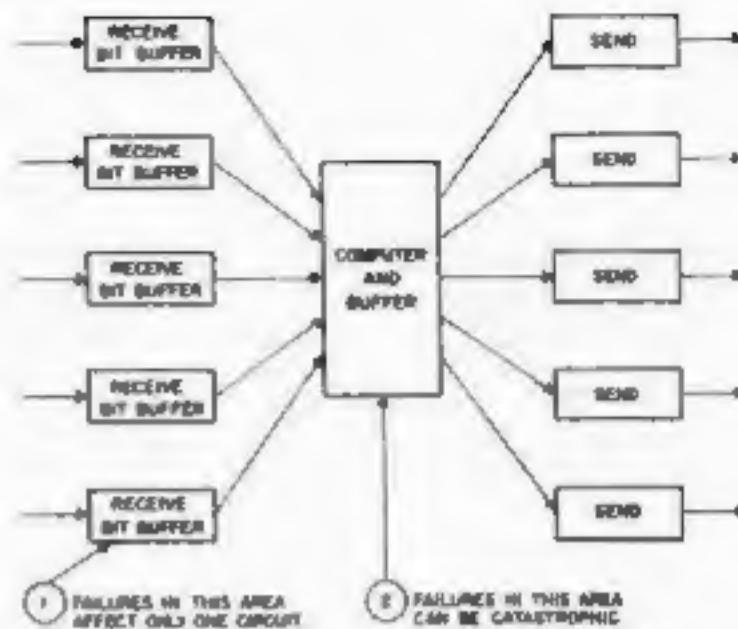


Figure 2. Computer-Controlled Switching System

The major components of a redundant computer-message switched system are shown in Figure 3. Either storage drum  $B_1$  or  $B_2$  and either scanner,  $C_1$  or  $C_2$ , can be connected to either processor,  $A_1$  or  $A_2$ . All tape units can be also connected to either processor by means of the switches shown in Figure 3. The communication channel positions have distributed operational functions and cannot fail catastrophically. Their reliability is, therefore, neglected in this analysis. The reliability of the switches is assumed to be sufficiently superior to that of the components, so that they have a negligible effect on the reliability of the system.

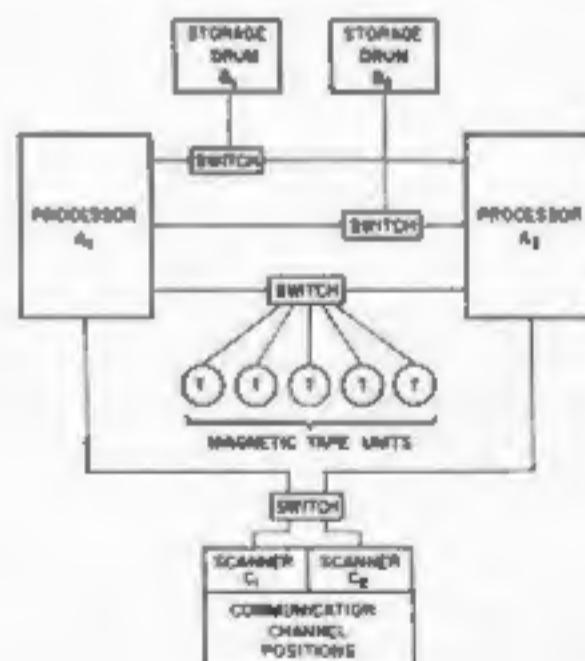


Figure 3. Computer-Switched Message System

Successful system operation is defined as the operation of either processor with either drum and either scanner, with at least two of the five tape units operating. Let

- $A_1$  = the condition — processor #1 is operable
- $A_2$  = the condition — processor #2 is operable
- $B_1$  = the condition — drum #1 is operable
- $B_2$  = the condition — drum #2 is operable
- $C_1$  = the condition — scanner #1 is operable
- $C_2$  = the condition — scanner #2 is operable
- $D$  = the condition — any two of the five tape units are operable.

The Boolean expression for the condition for system operation is

$$(A_1 \cup A_2) (B_1 \cup B_2) (C_1 \cup C_2) D$$

Assume that all units of a given type have identical reliability. Then,

$$R_{A1} = R_{A2} = R_A = 1 - \alpha \text{ where } \alpha \ll 1 \quad (8)$$

$$R_{B1} = R_{B2} = R_B = 1 - \beta \text{ where } \beta \ll 1 \quad (9)$$

$$R_{C1} = R_{C2} = R_C = 1 - \gamma \text{ where } \gamma \ll 1 \quad (10)$$

$R_D$  represents the probability that two or more tape units operate. This is one less than the probability that one will operate and four will fail. Therefore, in accordance with the Bernoulli Distribution Law:

$$R_D = 1 - \frac{5!}{4!} R_T (1 - R_T)^4 \quad (11)$$

( $R_T$  is the reliability of a single tape unit.)

Simplifying (11):

$$R_D = 1 - 5R_T (1 - R_T)^4 \quad (12)$$

Let

$$R_T = 1 - \epsilon \text{ where } \epsilon \ll 1 \quad (13)$$

Using (12) in (11), the expression for  $R_D$  becomes:

$$R_D = 1 - 5(1 - \epsilon) \epsilon^4 = 1 - 5\epsilon^4 \quad (14)$$

To find the system reliability,  $R_{sys}$ , apply the method illustrated in equations (1) through (5) to (7)

$$R_{sys} = [R_A (2 - R_A)] [R_B (2 - R_B)] \cdot [R_C (2 - R_C)] R_D$$

Using (8), (9), (10), and (14)

$$R_{sys} = (1 - \alpha^2) (1 - \beta^2) (1 - \gamma^2) (1 - 5\epsilon^4)$$

$$R_{sys} = 1 - 5\epsilon^4 - \alpha^2 - \beta^2 - \gamma^2 \quad (16)$$

To see the effect of redundancy on system performance, assume the following arbitrary reliability figures

$$R_A = 0.99, \quad \alpha = 0.01$$

$$R_B = 0.95, \quad \beta = 0.05$$

$$R_C = 0.99, \quad \gamma = 0.01$$

$$R_T = 0.90, \quad \epsilon = 0.10$$

The system reliability would then be

$$R_{sys} = 1 - 5(0.10)^4 - 0.01^2 - 4.05^2 - 0.01^2 = 0.9968$$

Thus, the system reliability is 99.68%, although the reliability of an individual component is as low as 90%.

#### Some Generalizations

In the introduction to this article, the concepts of distributed function systems and concentrated function systems were considered. Distributed function systems can more readily tolerate failures, since these result only in a lesser grade of service, rather than in a complete interruption of service. It is possible to examine the relative merits of various generalized configurations quantitatively to determine the effect on reliability of distributed systems' functions.

Assume that a system is made up of  $n$  independent components, each of which accommodates  $\frac{1}{n}$  of the total communications burden. If the reliability of an individual component is  $R$ , then the probability that  $k$  components will fail and  $(n-k)$  will operate is

$$\frac{n!}{k! (n-k)!} (1-R)^k R^{n-k} \quad (17)$$

This is the  $k^{\text{th}}$  term in the expansion

$$[R + (1-R)]^n \quad (18)$$

The probability that  $m$  or less units will fail is then the sum of the following terms in the expansion

$$\begin{array}{ll} R^0 & \text{none fail} \\ nR^{n-1} (1-R) & \text{one fails} \\ \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array}$$

$$\frac{n!}{m! (n-m)!} R^{n-m} (1-R)^m \quad m \text{ fail} \quad (19)$$

For the purpose of this article, let us define "Grade of Service" as that fraction of the communications job that will be accomplished if  $m$  components fail. Then, the percentage of the system in operation is given by:

$$\frac{n-m}{n} \quad (20)$$

Using these formulae, the probability of providing at least a required percentage of system operation can be determined. This is equivalent to the reliability with which that percentage of operation is offered, and is given by (19). Table I is a listing of these data.

To illustrate the results, reliability is plotted against percentage of system operating for the case  $R = 0.9$  in Figure 4. The three dots connected by a solid line represent a system consisting of three independent components ( $n = 3$ ). The four dots in triangles connected by a dashed line represent a system consisting of ten independent components. While the reliability for 100% system operation is better for the more concentrated system ( $n = 3$ ), the distributed system degrades more gracefully. It also provides higher reliabil-

ity for that percentage of operation below 100% than does the concentrated system.

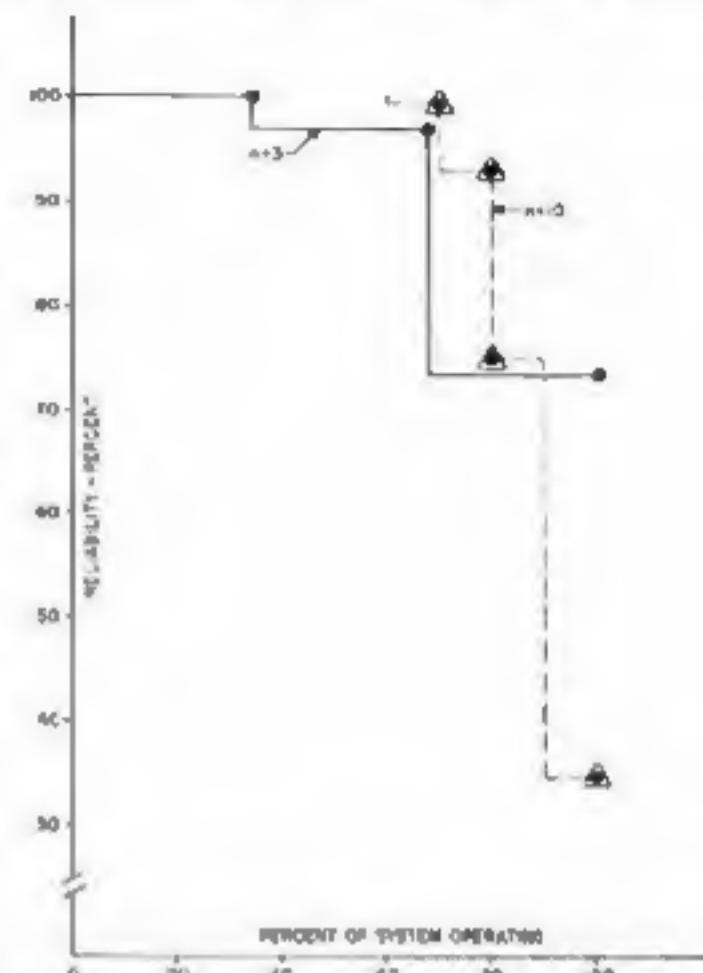


Figure 4. Comparison of Reliability for Concentrated Systems and Distributed Systems

Table I  
Reliability of Offering a Given Grade of Service  
Using  $n$  Components

| n   | no failures      |             | not more than one failure |              | not more than two failures |                   | not more than three failures |                              |
|-----|------------------|-------------|---------------------------|--------------|----------------------------|-------------------|------------------------------|------------------------------|
|     | Grade of Service | Reliability | Grade of Service          | Reliability  | Grade of Service           | Reliability       | Grade of Service             | Reliability                  |
| 1   | 100%             | R           | 0%                        | 100%         | 0%                         | 100%              | 0%                           | 100%                         |
| 2   | 100%             | $R^2$       | 50%                       | $R(2-R)$     | 0%                         | 100%              | 0%                           | 100%                         |
| 3   | 100%             | $R^3$       | 67%                       | $R^2(3-2R)$  | 33%                        | $R(R^2-3R+3)$     | 0%                           | 100%                         |
| 4   | 100%             | $R^4$       | 75%                       | $R^3(4-3R)$  | 50%                        | $R^2(3R^2-8R+45)$ | 25%                          | $R(4-6R+4R^2-R^3)$           |
| ... | ...              | ...         | ...                       | ...          | ...                        | ...               | ...                          | ...                          |
| 10  | 100%             | $R^{10}$    | 90%                       | $R^9(10-9R)$ | 80%                        | $R^8(3R^2-8R+6)$  | 70%                          | $R^7(120-315R+280R^2-84R^3)$ |

While the situation depicted is theoretical, it suggests that computers designed for communications systems should have their functions distributed for better reliability.

A number of alternate methods can be employed to achieve the higher reliability required in contemporary communications and information handling systems. The mathematical concepts described above apply particularly to the cases where equipment redundancy is suitable. This redundancy can be implemented on a number of levels. For instance, redundant individual circuits can be employed using "voting" techniques. Alternately, switchable, redundant components, such as memories, arithmetic units, discs, tape drives, etc. can be employed. Complete, duplicate switching centers can also be provided. Of course combinations of these methods can be employed.

Selection of the best method of increasing system reliability requires careful study of the system requirements and of the several available techniques. In this area, is the question of what constitutes a "failure." Plainly, communications system reliability requirements differ significantly from those of electronic com-

ponents or space vehicle systems. The mathematical concepts that pertain are however clearly related.

#### Trends

The laws of probability were developed as an instrument for the professional gambler to use on his unwary opponent. Through refinement, and by association with those of nobler ideal, the study of probability has achieved academic status. Now, it is applied to the attainment of reliability, an interesting evolution of its original objectives.

Reliability theory was developed in connection with missile and space programs where the dramatic results are viewed by all. The application of reliability theory to communications is less dramatic, but of equal importance. The time is not distant when all devices used for communications will have a recognized reliability specification, such as "mean-time between failures," which can be used in system reliability calculations. The design of reliability into systems is no longer based only upon the intuition of the designer.

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Feller, W. *Introduction to Probability Theory and Its Application*, Volume 1, 2nd edition, John Wiley & Sons, 1957.



BERNARD RIDER, Assistant Vice President, in the Government Communications Systems Department, is responsible for technical analysis, conceptual systems design, and applications engineering for government telecommunications and information systems.

Mr. Rider's experience has included the design of electronic circuits, digital and analog computers, radar mapping and bombing systems, radio and radiometric receivers, nuclear and electron spin resonance devices, and communications systems.

Before joining Western Union in 1964, he served as Director of Advanced Technology at Litton Systems.

He received his M.E. degree, with distinction in 1944 and his M.S. degree in 1946, both from Stevens Institute of Technology. He is a member of Tau Beta Pi.

# ***transcontinental microwave system expansion***

*Western Union plans to build a 1,300-mile extension of its trans-continental microwave system through the Pacific Northwest to interconnect with the cross-Canadian microwave network*

*Beginning at San Francisco, California the new \$13,000,000 extension will terminate at Aldergrove, British Columbia, where it will connect with the Canadian National-Canadian Pacific microwave system. Completion of the entire system is scheduled for the spring of 1967.*

*The system will also provide service for Seattle and Portland, Wash to meet the growing need for Western Union's public message requirements and private communications systems leased to government and military users.*

*The expanded microwave system encompasses 51 stations located over some of the country's most rugged terrain, the Cascade Range. Stations will be about 30 miles apart.*

*Initial capacity of the expanded system will be 1,200 voice-grade channels adding more than 31 million telegraph channel miles to the 80 million telegraph channel miles now provided in the company's present microwave network.*

*A complete electric power back-up will keep the network functioning, without interruption, in the event of commercial power failure.*

*The northwest extension will provide a fall-back between the compatible coast-to-coast Western Union and Canadian systems the eastern link of the two networks is located in the Buffalo, N. W. Toronto area*

*new*  
**punched card transmitter**  
*for*  
***data communications systems***

***Part III—operation***

—Newton Feld

The Punched Card Transmitter has been designed to sense both punched-hole and pencil-marked data which is recorded on IBM type business cards. The unit translates the sensed data to either the 5-level Baudot or 8-level ASCII code. It then transmits the data over a telegraph channel, in serial form, at speeds up to 100 words per minute.

Parts I and II of this article described the applications of the Transmitter to different types of communications systems. Part III discusses the theory of operation of the mechanisms and the electronic logic used in the transmitter.



Figure 1. Punched Card Transmitter (on the right) connected to Telegraph Channel together with a Western Union Teleprinter

The Punched Card Transmitter, shown in Figure 2, contains two basic modules, a mechanical section and an electronic section. The mechanical section, illustrated schematically in Figure 3, contains a card feed mechanism, a stylus assembly (read head) and a card indexing wheel. The electronic section contains power circuitry for controlling power supplied to the mechanical section, and logic circuitry for translating and transmitting the sensed information.

A  $\frac{3}{4}$ " gap is provided between two successive cards to allow for the automatic transmission of "carriage return" and "line feed" characters. This gap is produced by the continuously rotating neoprene feed roller which has three flats, as shown in Figure 3. The round portion of the feed roller drives the bottom card until the flattened section of the roller rotates to its top position. In this position, the card stack rests on the card gauge—not on the feed roller—and the driven card pauses.

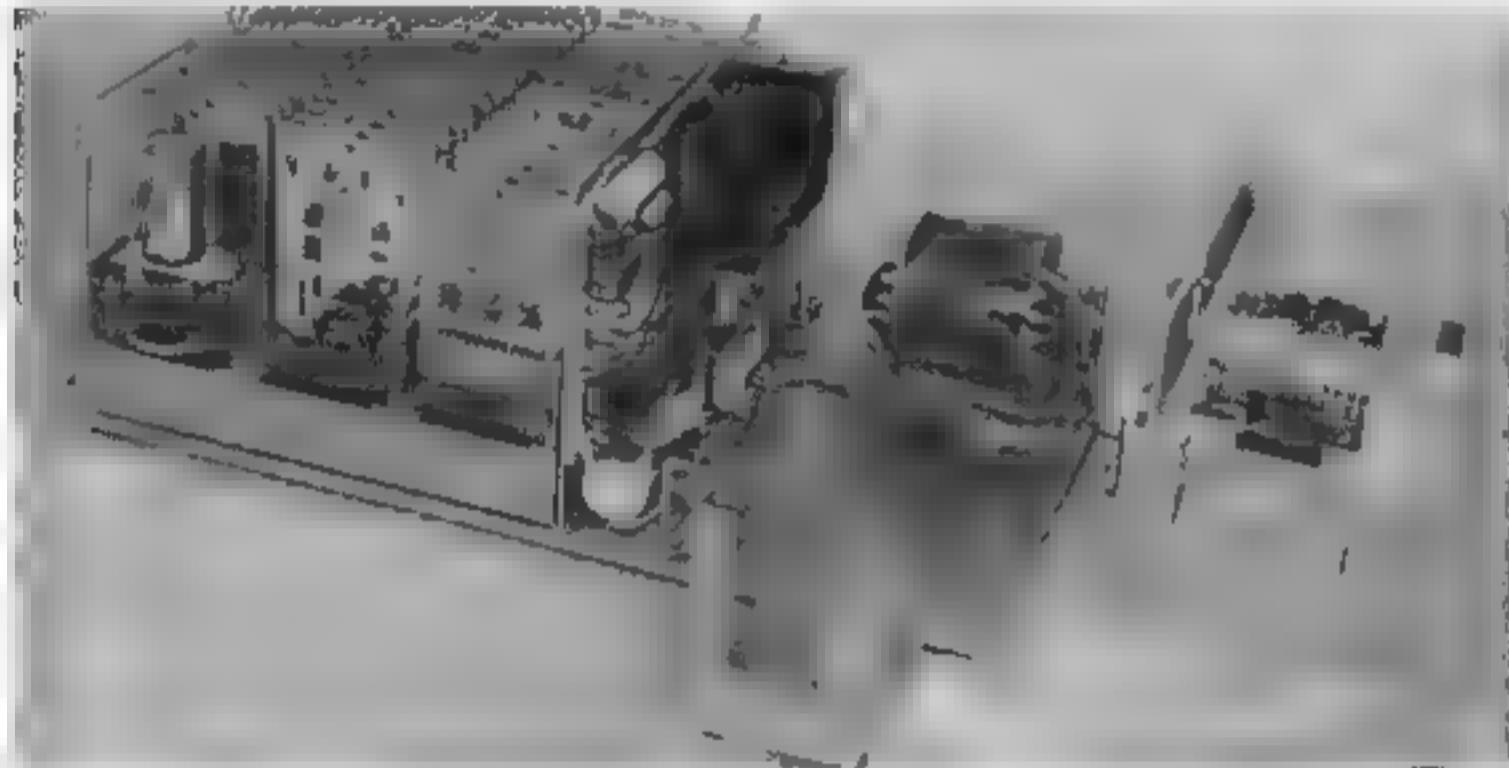


Figure 2. Two Basic Modules of Punched Card Transmitter  
—electronic section on left, mechanical section on right.

#### Card Feed

The card feed mechanism removes cards from the card bin and drives them under the stylus assembly where they are read. A stack of up to 150 cards may be placed in the card bin. As can be seen in Figure 3, at the start of the read operation, the leading edge of the bottom card rests on the feed roller. When the "start" button is depressed, the reader motor turns the two drive rollers and the feed roller, by means of a common gear train. The rotation of the feed roller causes a card to move between the top and bottom card gauges and between the drive and pressure rollers. As each card is fed from the card bin, the one above it drops down to take its place. The card gauges are designed to allow the feeding of only one card at a time to the drive rollers.

The card remains stationary until it is engaged by the second round section of the feed roller which rotates to the top position. The card is then driven to the first pair of drive and pressure rollers which drive the card under the read head as shown in Figure 3.

Thus a gap is introduced between successive cards as a result of the intermittent feeding action of the continuously rotating feed roller, and the constant driving action of the drive rollers. The width of this gap is independent of the length of the card being fed.

After the card is fed from the bin, it is driven under the stylus assembly and ejected into a card basket by the drive and pressure rollers.

A motor brake in the mechanical section can stop the feed mechanism on command. In units which translate data

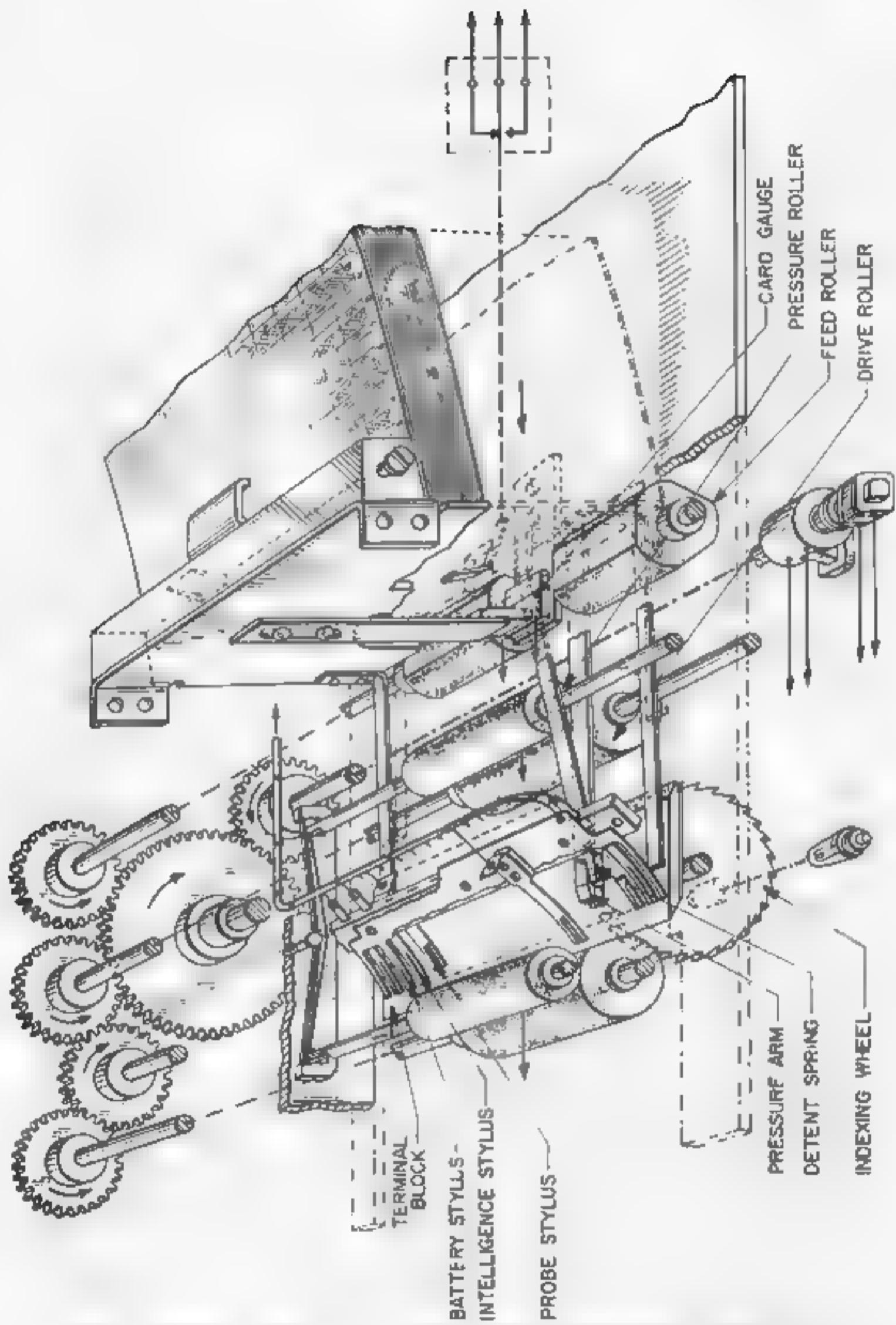


Figure 3. Schematic Drawing of the Mechanical Section of the Punched Card Transmitter

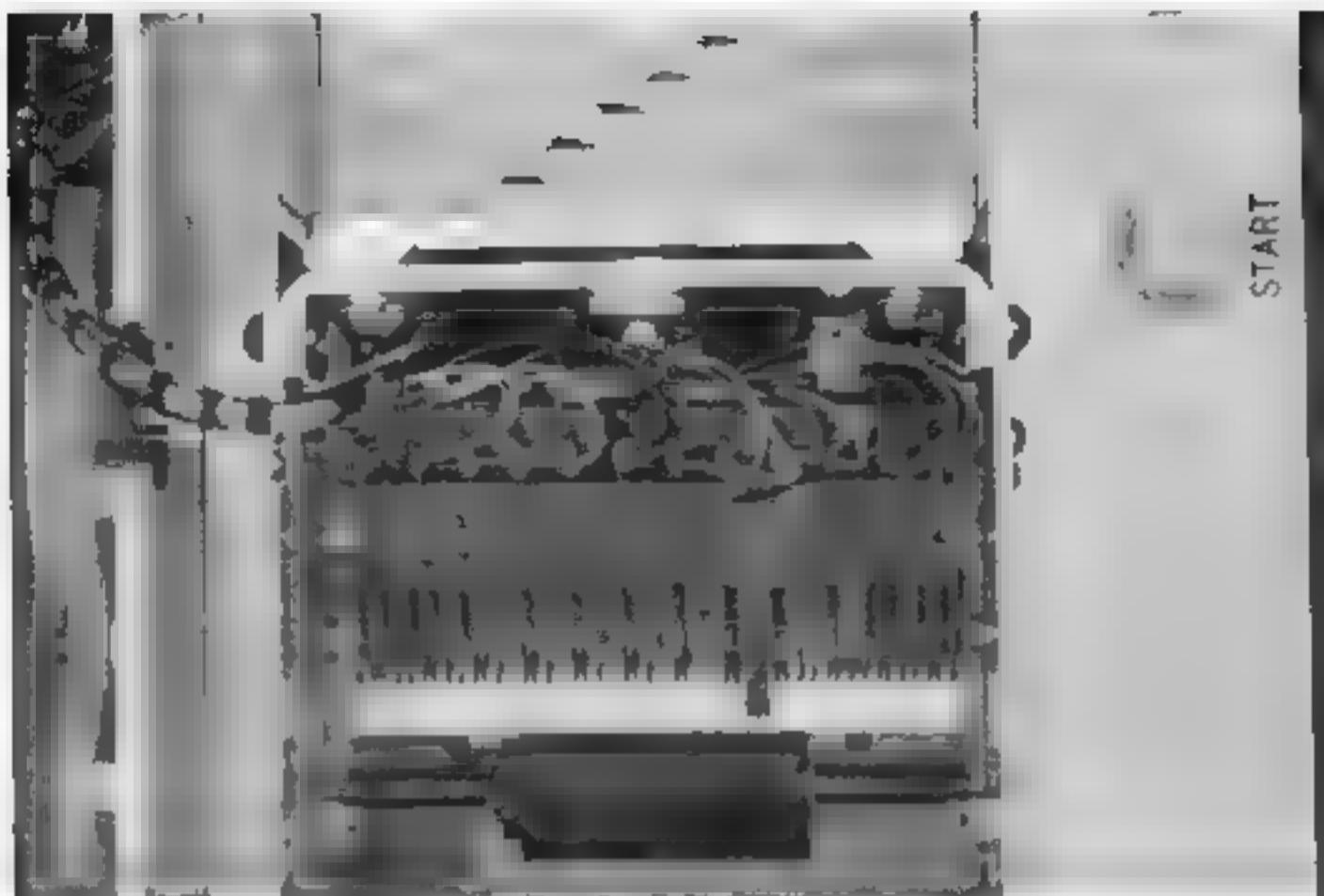


Figure 4. Stylus Assembly

to Baudot code, this brake is energized whenever an alpha character follows a numeric character, or vice versa. Stopping the card permits the electronic section to generate a Figures Shift or Letters Shift character. After the shift and sensed characters are transmitted, the brake is released and the card continues to feed through the unit. The brake may also be energized, on Baudot or ASCII code units, to permit insertion of external variable data. In this case, the brake is released either by an operator or automatically from control equipment. Finally, the brake may also be energized in cases of an alarm condition.

#### Read Head

The stylus assembly, illustrated in Figures 3 and 4, consists of twelve stylus stations which coincide with the twelve rows of information on a Hollerith-coded punched card. Cards are driven between the stylus assembly and the terminal block, and the punched-hole information is read when the intelligence stylus fall through the holes and make contact with the block. This

completes a circuit which allows storage of the character in the electronic section.

Each of the twelve intelligence stylus is associated with a pair of battery stylus, one on either side of the intelligence stylus. These battery stylus enable the intelligence stylus to sense pencil marks, because pencil lead forms a conductive path between the intelligence and battery stylus. A battery pulse through the pencil mark has the same effect on the intelligence stylus as a battery pulse from the terminal block, and the sensed character is stored in the electronic section. The straddling configuration provides two conductive paths from battery to intelligence, and greatly increases mark-sensing reliability.

Front and rear probe stylus are mounted on the assembly for sensing the front and rear edges of each card. When the rear probe falls off the card, an end-of-card signal (CR, LF) is generated. In addition, the probes blind the electronic circuitry and prevent transmission of false characters before column 1 and after column 80 on the card.

## Indexing Wheel

When transmitting data, it is important that the original field format be duplicated at the receiving station. Since fields of punched information may be separated by skipped or blank columns on a card, it is necessary to transmit a character for each column on the card, and to identify the skipped columns by transmission of a spacing character. Generation of the required characters is achieved by the indexing wheel assembly illustrated in Figure 3.

Before passing under the stylus assembly, cards are driven between a pressure arm and an indexing wheel. While being driven under the stylus, the card drives this wheel. The indexing wheel contains ratchet-type teeth spaced around its circumference so as to coincide with the spacing of the columns on the punched card. These teeth serve three purposes:

- They "bite" into the card so that the card can drive the wheel with minimum slippage.
- They are used to provide timing signals.
- They are used in detenting the wheel after each successive card.

A photocell and light source are mounted opposite each other on either side of the wheel. As the wheel rotates, the teeth in the wheel pass between the lamp and the photocell, thus generating timing pulses. These pulses initiate either transmission of a character when a hole is sensed by the intelligence stylus or transmission of a "space" for a blank column in the card.

At the end of the card, the detent spring, shown in Figure 3 falls between two teeth and detents the wheel in its home position. This detenting action prevents loss of synchronization between the tooth timing pulses and column positions on successive cards. Each card starts turning the wheel from the same relative position, since the wheel does not begin to turn until the leading edge of a card contacts a ratchet tooth.

Since the indexing wheel is driven by the card, accurate card position signals are transmitted to the electronic circuitry, even when there is slippage between the card and the friction driving rollers.

## Electronic Timing Logic

Primarily, the function of the electronic circuitry is to convert the parallel 12-bit output of the mechanical reader into a serial 5- or 8-unit code. To accomplish this function certain controls and safeguards must be provided.

The mechanical reader employs a continuous friction feed method to drive the punched cards. Such a method does not provide the electronic circuitry with the necessary positive indication of when to read for a character. However, by utilizing the signals generated from the indexing wheel, this problem of when to read and translate can be eliminated.

The timing sequence of the electronic circuitry is shown in Figure 5. Normally, the sensing circuitry is in a "read" condition, searching for the stylus output of the mechanical reader. The generation of a pulse from the indexing wheel will start the counter which is normally held in the last part of the "rest pulse position." The counter begins to cycle, thus supplying the necessary timed pulses for a serial output. During the completion of the rest pulse and the generation of the start pulse, the sensing circuitry continues to search for the stylus read signal. Any 12-level information sensed during the search period will be read and stored in the storage section. At the end of the start pulse, the sensing circuitry is put in a non-read condition. Meanwhile, the stored information is converted to its equivalent 5- or 8-unit code by the translator circuitry. This translated information is fed directly to the pulse distributor section where it is combined with the timed pulses of the counter for a serial output. The counter is returned to its stop position after clearing the storage section at the completion of the transmission of intelligence, and after the storage circuitry begins its search for the next character.

An important feature of the electronic circuitry is the automatic conditioning of the receiving equipment. In instances where the receiving equipment is a teleprinter, the problem of overlining arises. To prevent this, automatic carriage return line-feed sequences are generated at the

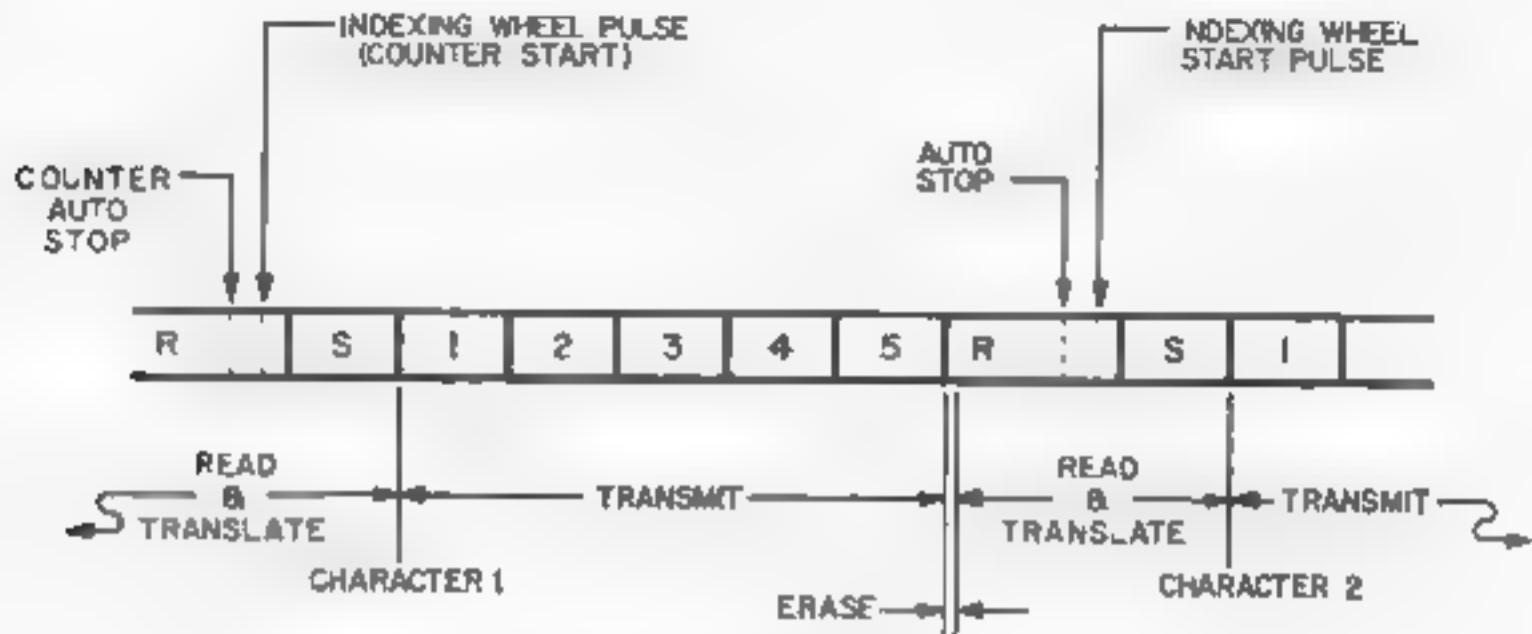


Figure 5. Timing Sequence for the Electronic Section

start of transmission and thereafter at the end of each card

For 5-unit code teleprinters the additional problem of Figures and Letters shift functions must be considered. In the Baudot 5-unit code, most code combinations represent two characters. To differentiate between them, Figures and Letters cases are used. In the Hollerith 12-level punched card code, however, each character has its own code combination, and no shift functions are provided. Therefore in translating from 12-level code to 5-level code, the electronic circuitry must automatically insert the necessary Figures and Letters shift functions.

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2. New Punched Card Transmitter for Data Communications Systems. Part II - Punched-Hole and Pencil-Mark Sensing Modes. N. L. Feld, Western Union TECHNICAL REVIEW, Vol. 19, No. 3, July 1965.

#### Acknowledgements

The author wishes to acknowledge that the improved model of the Punched Card Transmitter was engineered under the supervision of Mr. W. V. Johnson, Senior Engineer. The electronic circuitry of the unit was designed by Mr. M. J. Casey Project Engineer.

NEWTON L. FELD, Project Engineer in the Information Systems & Services Department, has been concerned with the design and development of Punched Card Transmitter 11890-A since its inception.

When he joined Western Union in 1961, he was assigned to the Ocean Cables Division where he was involved in the modification of Start-Stop Distributors 47 A. In 1962, he was assigned to the Telegraph Equipment Division where he has been concerned with the design of electro-mechanical mechanisms for use in teleprinter equipment. He participated in the conversion of the Model 19 ASR Set for Telex use.

Mr. Feld received a Bachelor of Mechanical Engineering Degree from the Cooper Union School of Engineering in 1960. He was a Teaching Fellow at the Polytechnic Institute of Brooklyn from 1960 to 1961, and received a Master of Mechanical Engineering Degree from that Institute in 1962.



## *transistorized*

# *data network repeater*

—Harry C. Likel

### **Characteristics**

The principal function of a network repeater is to provide a means whereby three or more drops may be interconnected in such a way that messages from any one drop may be received by all.

To fulfill this function satisfactorily it is sometimes necessary that a network repeater also have some of the following attributes.

#### • Anti-Home Record Copy Circuit

It should be possible to set the repeater so that it will or will not return the drop's signal to the sender. The circuit used to blank out the return signal when it is not wanted is known as the "anti home record copy circuit." This circuit is also needed when network repeater is required to operate with another network repeater at a distant location, as is the case when the network has multiple drops in a number of cities. If this type of circuit is not used, the network repeaters facing one another very quickly lock one another on "spacing," thus tying up the circuit.

#### • Lock Out Circuit

In a network in which the drops have free access to the circuit, a drop, through inadvertance, may start to send when another is already sending. Of course, this "breaks up the circuit." To prevent it, requires that extra circuitry in the network repeater lock out all other drops when one starts to send and—to remove the lock

after "steady marking" (the idle condition) has been on the circuit long enough to indicate that sending has ceased. As a general rule, this circuit is not used unless it is needed, because at the end of each message, it must insert an enforced idle time of at least one or two letters. One letter is needed for start-stop sending and two letters are used with synchronous transmission.

#### • Connection for Regenerator

A network repeater, which is to be used on circuits that require regeneration, should provide means to connect a single regenerative repeater into the circuit, in such a way, that it will regenerate the signals of all the drops connected at that location.

#### • Open Circuit Blind

Since the input to a network repeater set-up has the characteristics of a series circuit, any drop which goes "open" or sends a steady spacing signal, will make the entire network inoperative. If for some reason, a drop "goes open" or sends "spacing" for perhaps, one second, the network repeater will automatically substitute "marking" for the input from that drop.

In addition to the above, certain manual controls, jacks, test points and some audible and visual signals are required in a network repeater. The signals inform the technician of the condition of the circuit.

## Early Development

Over the years Western Union has developed network repeaters and auxiliary equipment which provided all of these necessary functions. However, because these repeaters use relays, therefore they are limited in their speed of operation. For this reason, in 1957, when the need to operate high speed data communications networks seemed imminent, a simple transistorized unit known as Data Network Repeater 9614 A, was devised and used experimentally. It showed, in some situations, a repeater with all the attributes mentioned above was required. Therefore, another project was initiated to add the required features. It was decided to make the unit self contained.

A panel of these units takes up more room at the operating position, but if a unit becomes defective, a swap results in a change of everything associated with the circuit. However, the need in larger installations for greater concentration at the operating position is so great, that in most installations, the jacks and signal lights may be remote from the unit.

## Transistorized Repeaters

Network repeaters 11622-A and 11724-A are the result of the above development. Network Repeater 11622-A has all the features already described and should be capable of meeting the requirements of any circuit. Network Repeater 11724-A, intended for use in less demanding service, is essentially a repackaging of three of the original type 9614-A repeaters on one 11622-A Chassis. Therefore is capable of serving three drops.

The digital portion of Western Union data circuits operate on a ten milliampere polar basis with both source and sink impedance of 600 ohms. The new network repeaters are designed to operate in this environment. However, the signal circuits of both repeaters have no low-speed limitations and the auxiliary circuits of the 11622-A will operate at speeds as low as 60 WPM telegraph signals. Therefore, with the addition of suitable adapters they may be used on conventional telegraph circuits.

## Operation

The operation of the various circuits is as follows.

### Dummy Circuit

The dummy circuit is defined in the "Western Union's Fundamental Technical Glossary" as: A local circuit connecting together several network repeaters.

This circuit has two parts: the common input circuit and the common output drive circuit. Study of the schematic diagrams of the two network repeaters (Figures 1 and 2) will show that when a number of repeaters are connected together by green cords between their "dummy out" and "dummy in" jacks, a jack of one kind being left empty at the one end of the set-up, and a jack of the other kind left empty at the other, the input circuit which results will be as shown in Figure 3. The sending side of each drop is connected to the base of the  $Q_1$  transistor which will conduct, thus bringing the junction of  $R_4$  and  $R_5$  positive. If anyone of the drops sends spacing, its  $Q_1$  transistor will open the circuit from the junction of  $R_4$  and  $R_5$  to ground and—since  $R_4$  plus  $R_5$  is a lower resistance than  $R_6$ , the junction between  $R_4$  and  $R_5$  will now be negative.

Therefore, an inverted replica of the signal sent by any drop will appear at this point in the network repeater that has no plug in its "dummy in" jack. The signal is again inverted by  $Q_1$  and applied to the sleeves of the "dummy in" and "dummy out" jacks. The cording between repeaters connects all the sleeves together and sets up the output drive circuit. Each network repeater has its own polar line driver circuit to send to the drop. This circuit consisting of transistors  $Q_2$ ,  $Q_3$ ,  $Q_4$  and  $Q_5$  is connected to the common drive circuit through isolating resistor  $R_7$ . Thus, any one drop's sending will be repeated to all the connected drops.

### Anti-Home Record Copy Circuit

In the schematic for Network Repeater 11724-A, shown in Figure 1,  $Q_7$ ,  $Q_{14}$  and  $Q_{15}$  are the transistors which make it possible to prevent a signal from being returned to the sender. In the section No. 1 of Figure 1, the signal from the connected

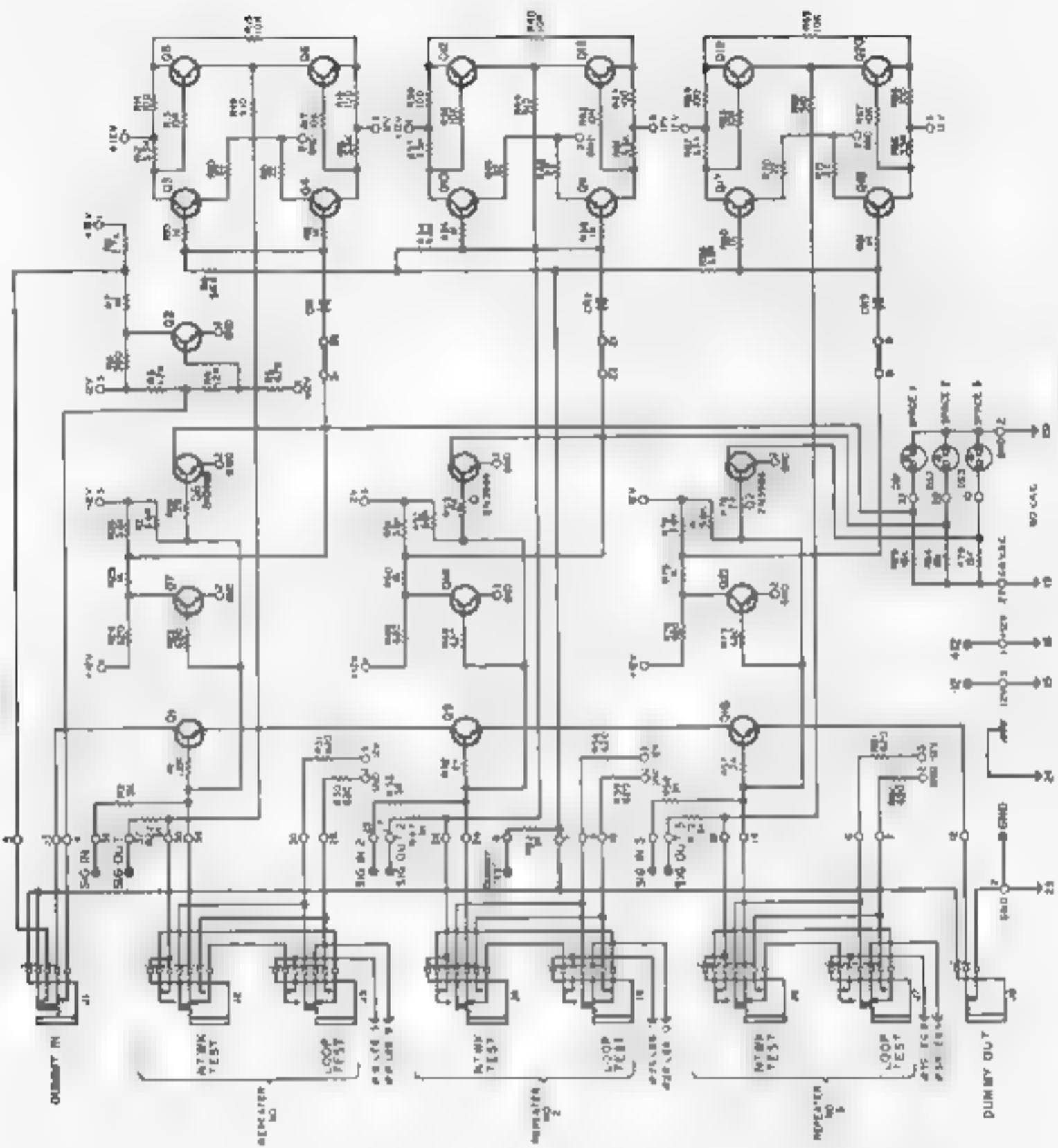
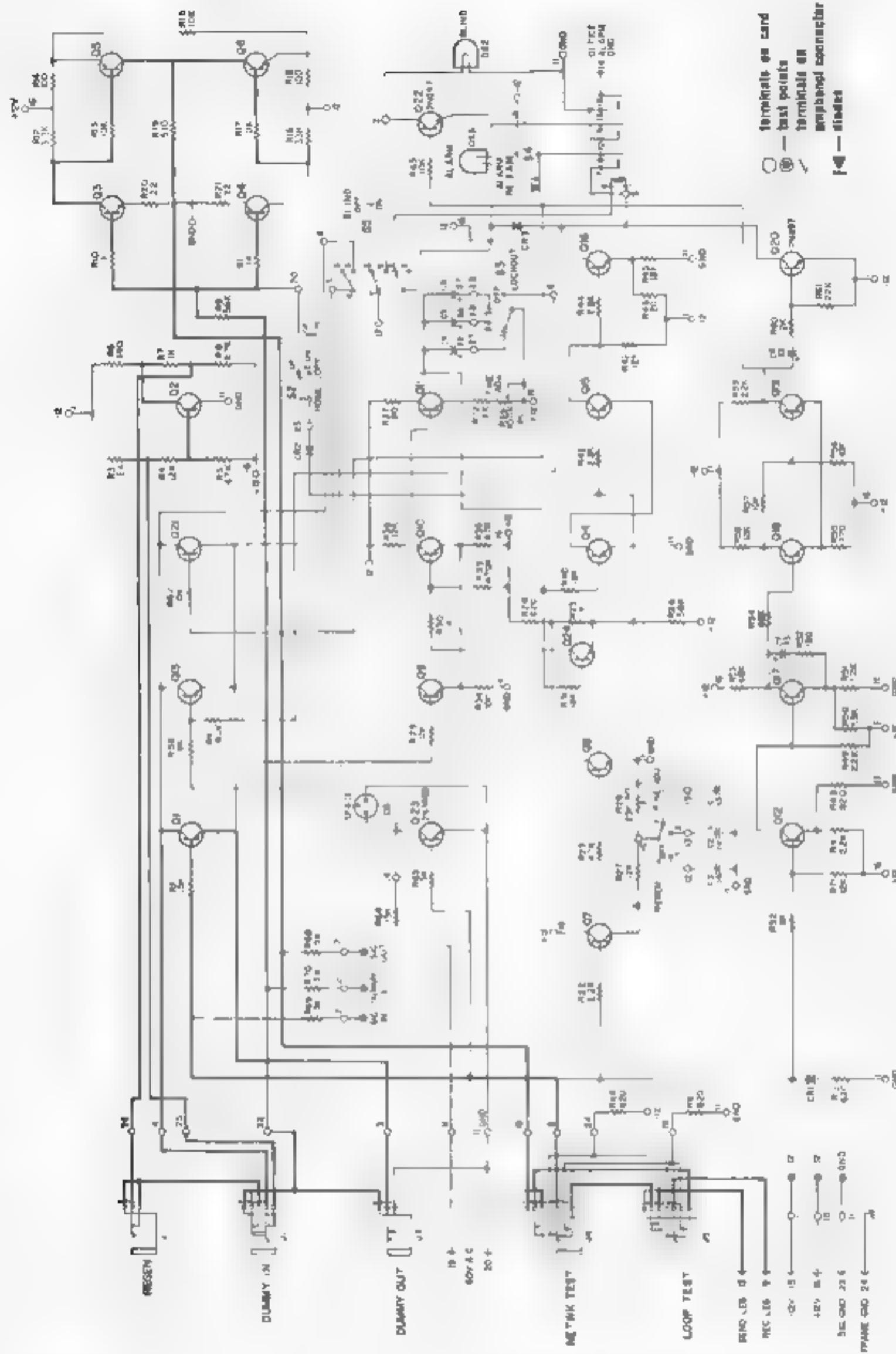


Figure 1. Schematic Drawing for Network Repeater #11724-A



drop is applied to the base of  $Q_7$ . In a similar fashion to that described for  $Q_1$ ,  $Q_7$  provides an inverted signal, in this case at the junction of  $R_{14}$  and  $R_{24}$ . The negative part of this signal is applied through the link between 29 and 31, and CR1, to the input of the No. 1 section line driver. Here, it overcomes the spacing signals applied to the other side of isolation resistor  $R_7$  by the common drive circuit, and holds the output on "marking" when the input signal goes to "spacing."  $Q_{14}$  and  $Q_{24}$  perform the same function in sections No. 2 and No. 3. If "home copy" signals are wanted the appropriate link or links between 29 and 31, 21 and 23, and 9 and 11 must be removed.

The circuitry required to implement the "anti home record copy" function in Network Repeater 11622-A is somewhat more elaborate because of the possibility that a regenerative repeater may be used in conjunction with the 11622-A Repeater. This will be explained at the end of the next section.

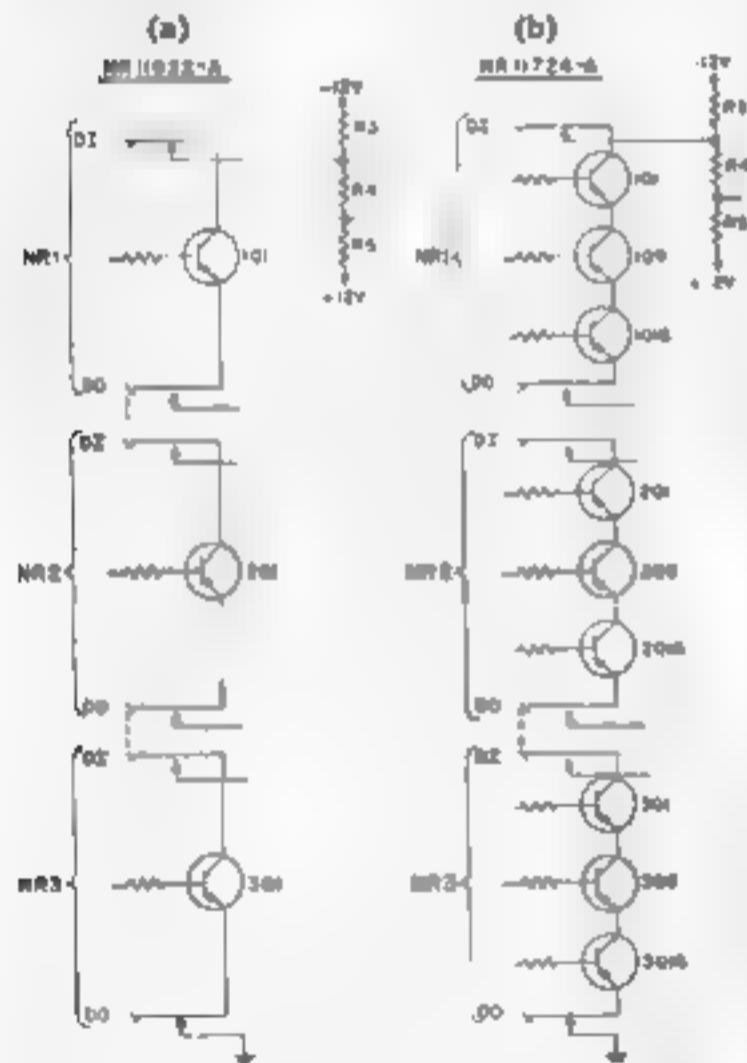


Figure 3. Functional Diagram of Network Repeaters a) type 11622-A b) type 11724-A

#### Regenerative Repeater

When a regenerative repeater is used in the set up, it is plugged into the regen jack of the Network Repeater 11622-A. It is fed the signal from the common output drive circuit, through the cord tip circuit. The regenerative repeater returns the regenerated signal through the cord sleeve circuit. It is applied to the sleeves of the "dummy in" and "dummy out" jacks by the sleeve circuit of the cords in the "dummy in" and "dummy out" jacks and then to the polar line drivers in each repeater. The difference in this situation is that the signal applied to the polar line drivers by the "regen" is delayed by one half a bit relative to the signal applied to the input. Because of regeneration it is now impossible to cancel the "spacing" part of the signal in any repeater merely by inverting the input signal and using the "marking" side of the inverted signal to override the spacing signals at the input to the polar line driver. The effect of the spacing pulse in the cancellation circuit must endure a minimum of one half bit beyond the end of the spacing pulse at the input. The circuitry of  $Q_1$  and  $Q_7$  accomplishes this. When the signal applies "spacing" to the base of  $Q_7$ , it conducts.

The potential drop in  $R_{27}$  allows  $Q_7$  to conduct immediately and ground the junction of  $R_{14}$  and  $R_{24}$ . The junction of  $R_{14}$  and  $R_{24}$  then becomes negative and this is applied through CR2 and S2 to the input of the polar line driver, which it will hold on "marking" when the common drive circuit applies spacing to the other side of  $R_7$  one half bit later. While the input signal remains on spacing,  $Q_7$  also charges one of the timing capacitors  $C_1$ ,  $C_2$  or  $C_3$ , which is selected according to the speed of the circuit. When the input signal goes to "marking" and  $Q_7$  ceases to conduct, this capacitor discharges, partly through  $R_{26}$  and partly through  $R_{14}$  and  $R_{24}$  and  $Q_7$  in parallel. This action holds  $Q_7$  conducting and the output of the repeater on "marking" until the capacitor is almost discharged. The time duration of this action may be set by adjustment of  $R_{26}$  to last until marking reappears on the common drive circuit.

#### Anti-Break-In Circuit

As mentioned earlier when one drop in a network starts "sending," it may be desirable to lock out the sending side of all other drops in the network until sending ceases. This is made possible in the 11622-A network repeater by the circuitry of  $Q_{10}$ ,  $Q_{11}$ ,  $Q_{12}$ ,  $Q_{13}$  and  $Q_{14}$ . If either  $Q_{10}$  or  $Q_{11}$  are conducting  $Q_{12}$ 's base and emitter will be near ground potential. When this is the case,  $Q_{13}$  will be non-conducting and  $Q_{14}$  will have control of the input side of the dummy.  $Q_{14}$  stops conducting when the common output drive circuit goes spacing but in the repeater whose drop is doing the sending, conduction by  $Q_{10}$ ,  $Q_{11}$  and  $Q_{12}$  keep  $Q_{13}$  conducting and in that repeater  $Q_{14}$  will retain control of the dummy circuit.

In the remaining repeaters in the network there will be marking at the input to  $Q_{14}$  which will result in  $Q_{13}$  being non-conducting. This allows  $Q_{12}$  to conduct and charge  $C4$ ,  $C5$  or  $C6$ , the capacitor in use depending upon the speed of the circuit. When this capacitor becomes charged to a point where its negative terminal is sufficiently different from ground potential,  $Q_{13}$  will conduct, shorting out  $Q_{14}$  and leaving the original sender the only drop with access to the network. When "sending" ceases the charge in the capacitor will dissipate through  $R_{11}$  and  $R_{39}$ . The capacitor used and the setting of  $R_{39}$  must result in  $Q_{13}$  being held conductive for a period just greater than the longest one that can occur between spacing pulses in normal operation of the network.

#### Break-In Alarm Circuit

The break-in-alarm circuits, consisting of transistors  $Q_{14}$ ,  $Q_{15}$ ,  $Q_{16}$  and associated circuitry operates the alarm relay (K1) which in turn lights the alarm light and closes the office alarm circuit when a drop either starts to send or its sending leg goes "open" or "spacing" while another drop is "sending."  $Q_{14}$  is controlled by the potential across the lockout timing capacitor and will conduct if another drop is sending.  $Q_{15}$  conducts when the local drop is sending. If both  $Q_{14}$  and  $Q_{15}$  conduct at the same time,  $Q_{16}$  will be made conducting

and operate K1 which performs the necessary alarm functions.

#### Open Line Blind Circuit

The requirement that the repeater automatically eliminate from the network the sending leg of a drop if it goes open or spacing for more than, one second, is implemented by the circuitry of  $Q_{17}$ ,  $Q_{18}$  and  $Q_{21}$ . Transistor  $Q_{17}$  conducts only in the presence of a marking signal from the drop. Conduction in  $Q_{17}$  causes  $Q_{18}$  to conduct also. When  $Q_{18}$  is conductive,  $C7$  must be discharged and  $Q_{19}$ , which with  $Q_{21}$  forms a Schmidt trigger, will be the conducting member of the pair. Should the drop go open or to spacing,  $Q_{18}$  and  $Q_{19}$  will no longer conduct and  $C7$  will charge. The constants of the charging circuit are chosen so that in approximately one second the potential at the base of  $Q_{19}$  causes it to be non-conducting and as a consequence  $Q_{21}$  will be conducting. When  $Q_{21}$  conducts, the potential at the base of  $Q_{17}$  becomes positive, relative to its emitter, and it conducts, short circuiting  $Q_{18}$  and "blinding" the drop's sending leg. At the same time, the change of state of the Schmidt trigger causes a positive pulse to be applied through  $C8$  to  $Q_{16}$ .  $Q_{16}$  conducts long enough in response to this pulse to cause K1 to pull up and lock through contacts 6 and 7, thus sounding the alarm and lighting the appropriate lamps. Should the sending loop of the drop go to marking,  $Q_{16}$  would again become non-conducting causing  $Q_{15}$  to remove the lockout from the drop. It should be noted that the blind lamp was lit through  $Q_{18}$  and that it will now go out. However, the alarm lamp will remain lit to inform the operations technician which drop was responsible for sounding the alarm.

The purpose and operation of the space lamps, the various jacks provided and the manual blind switch, the latter of which is only found on the Type 11724-A repeater, is self evident. Blinding is accomplished in the 11724-A Repeater by inserting a plug in the appropriate loop test jack. Various protected test points are provided for the convenience of the operations technician.

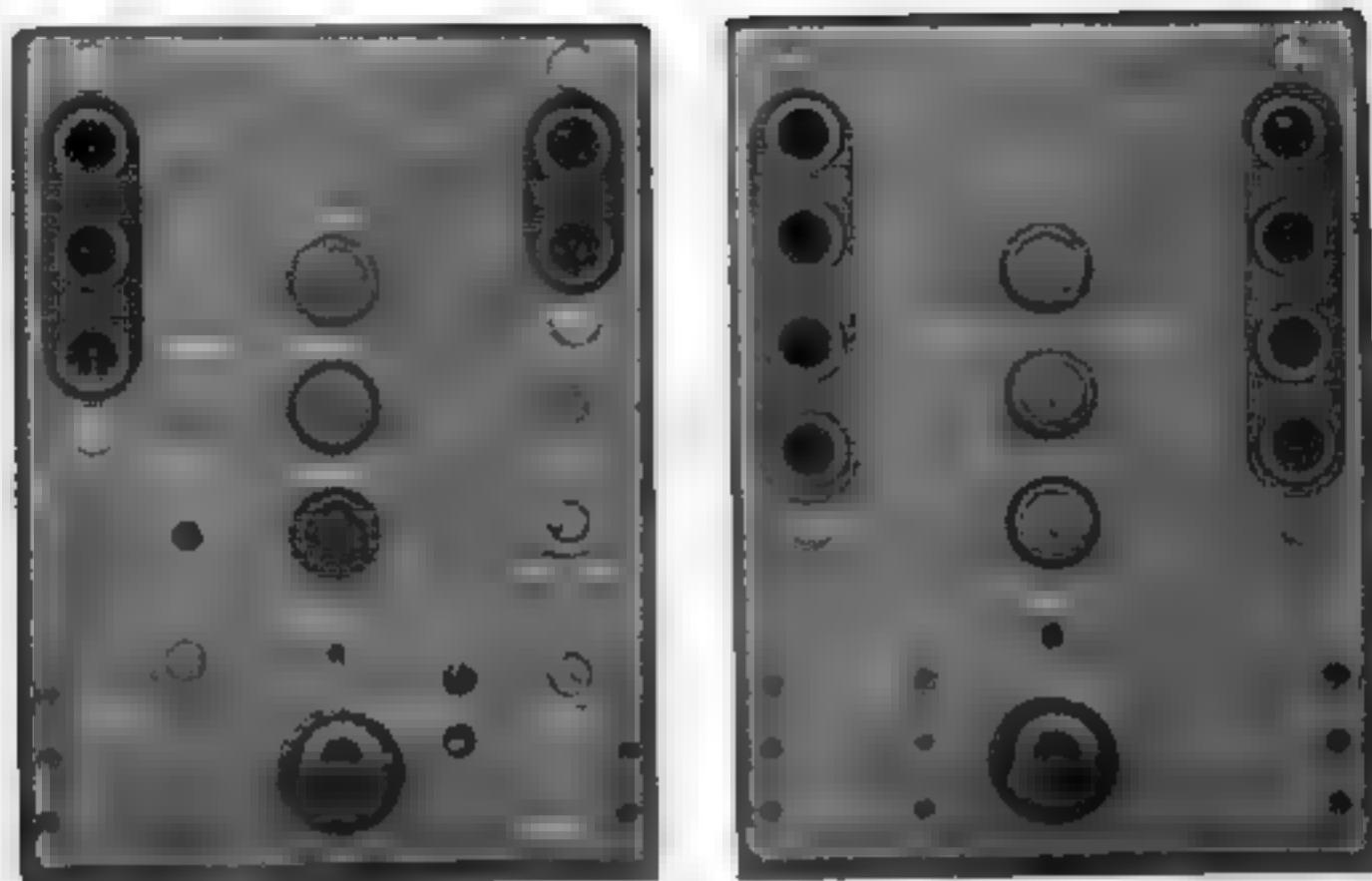


Figure 4. Front panel of the two Transistorized Network Repeaters

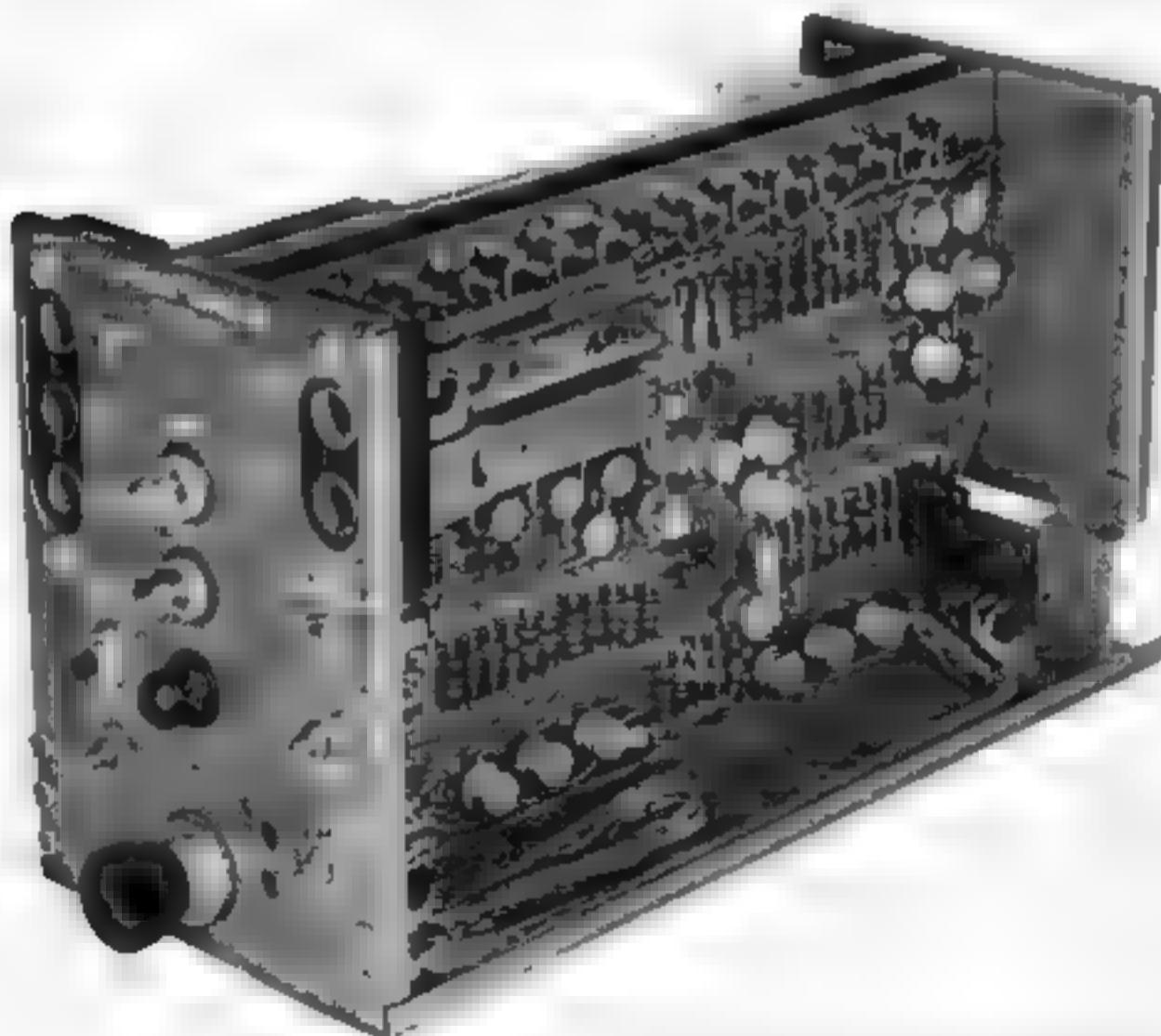


Figure 5. Side View of Transistorized Network Repeater #11622-A showing internal components

## Conclusion

At present there are almost nineteen thousand different types of old style network repeaters in use in Western Union. The new transistorized repeaters were designed to replace the old units. A few type 11724-A repeaters have been in service for less than one year and have operated satisfactorily. They are less expensive, use less power, and when used without a leg adapter occupy approximately one-twentieth the space required by the older units. With leg adapter 12120-A or 12121-A, which a low operation with 120 V legs, this ratio is reduced to one fourteenth to one.

The 11622-A Network Repeater, with its many capabilities also has a size advantage over the older repeaters of approximately seven to one when working

alone and four and one-half to one when working with a leg adapter. Figure 4 illustrates the two types which are similar in size, but different in makeup. The front panel of these repeaters measures 3 3/4 in. by 5 1/6 in.

Figure 5 is a side view of the Type 11622-A Repeater showing the component parts. The overall depth of the unit—10 inches.

It is expected that the improvement in reliability and reduction in maintenance usually experienced when old style apparatus is replaced with transistorized equipment will result. It is likely that the new units will replace the old units in locations where limited space, reliability and maintenance are important factors.



**HARRY C. LIKEL**, senior engineer in the Information Systems & Services Department, has been responsible for such developments as the Mod Amp Group, and the Data Channel Combiner used in the AUTODIN Switching System.

Mr. Likel received his degree in Electrical Engineering from the Polytechnic Institute of Brooklyn in 1930. He holds a registered New York State Professional Engineers License and is a senior member of the Institute of Electrical and Electronics Engineers.

He is a consulting member of the Association of American Railroads Committee on Transmission. He holds a number of issued patents and several pending applications.

# *circuit switching network for advanced record system*

—Howard E. Brooks

The Advanced Record System which WU is providing the General Services Administration is a combined circuit switching and message switching system. An article on the overall system which appeared in the January 1966 issue of the Technical Review covered the interrelation of the Circuit Switching Network and Message Switching Centers.<sup>1</sup>

» The Circuit Switching Network utilizes two types or levels of switching offices. The offices on which the subscriber lines terminate are called the District Offices. The offices which perform tandem or trunk switching are termed Junction Offices. This article is limited to the narrowband capability of the District Offices (DO) although all offices are capable of switching narrowband teleprinter signals (up to 150 bauds) and wideband circuits (up to 48 KC).

## **District Office**

The equipment for a typical DO (designed and manufactured by ITT Federal Laboratories) is shown in Figure 1. The cabinet on the left contains common control units, i.e., registers, markers and program panels. Each unit consists of one or more modules. The center cabinet contains the line circuit modules and the matrix modules. The cabinet, on the far

right, contains the trunk and link modules, trunk group relays and the register access matrix. Not shown in the photograph are the batteries, Intermediate Distribution Frame, power and distribution rack and the rack containing the trouble indicator and traffic meters.

Most of the modules are of the plug in-type and are mounted in subracks or shelves within the cabinets. Modules are interconnected by means of wire-wrap connections on the backplane of the subracks, which are interconnected by means of cables with connectors on both ends. Variable cross-connections are made by means of cables which terminate on the Intermediate Distribution Frame (IDF). This plug in arrangement permits an office to be installed with sufficient equipment to meet the initial requirements. Then, as expansion is required, additional modules can be plugged into vacant positions in the subracks.

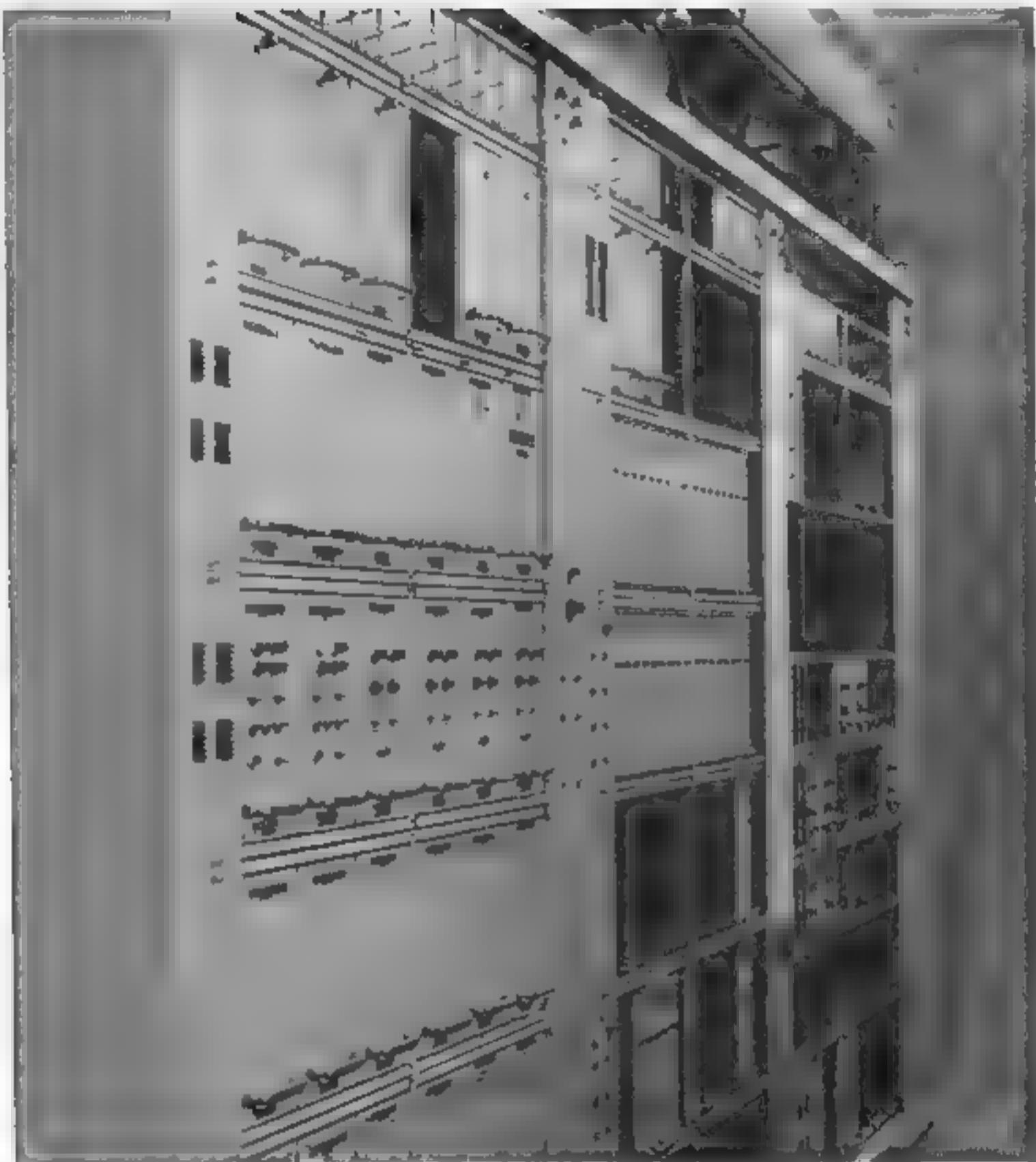


Figure 1 Typical District Office Installation

A typical District Office installation is illustrated in Figure 2. All common functional units are duplicated for reliability and continuity of service. Briefly, their functions are as follows.

- The matrix provides a means through which the switched transmission path is established
- The line circuits provide termination for the teleprinter units
- The trunk circuits interconnect the switching equipment and the transmission

facilities between offices

- The link circuits provide the means for interconnecting two subscribers in an intra-office call
- The register-sender accepts address information from the calling subscriber or incoming trunk. It also transmits information to the next office for an interoffice call
- The marker, the major control unit, assigns registers as required, and establishes the proper paths through the matrix.

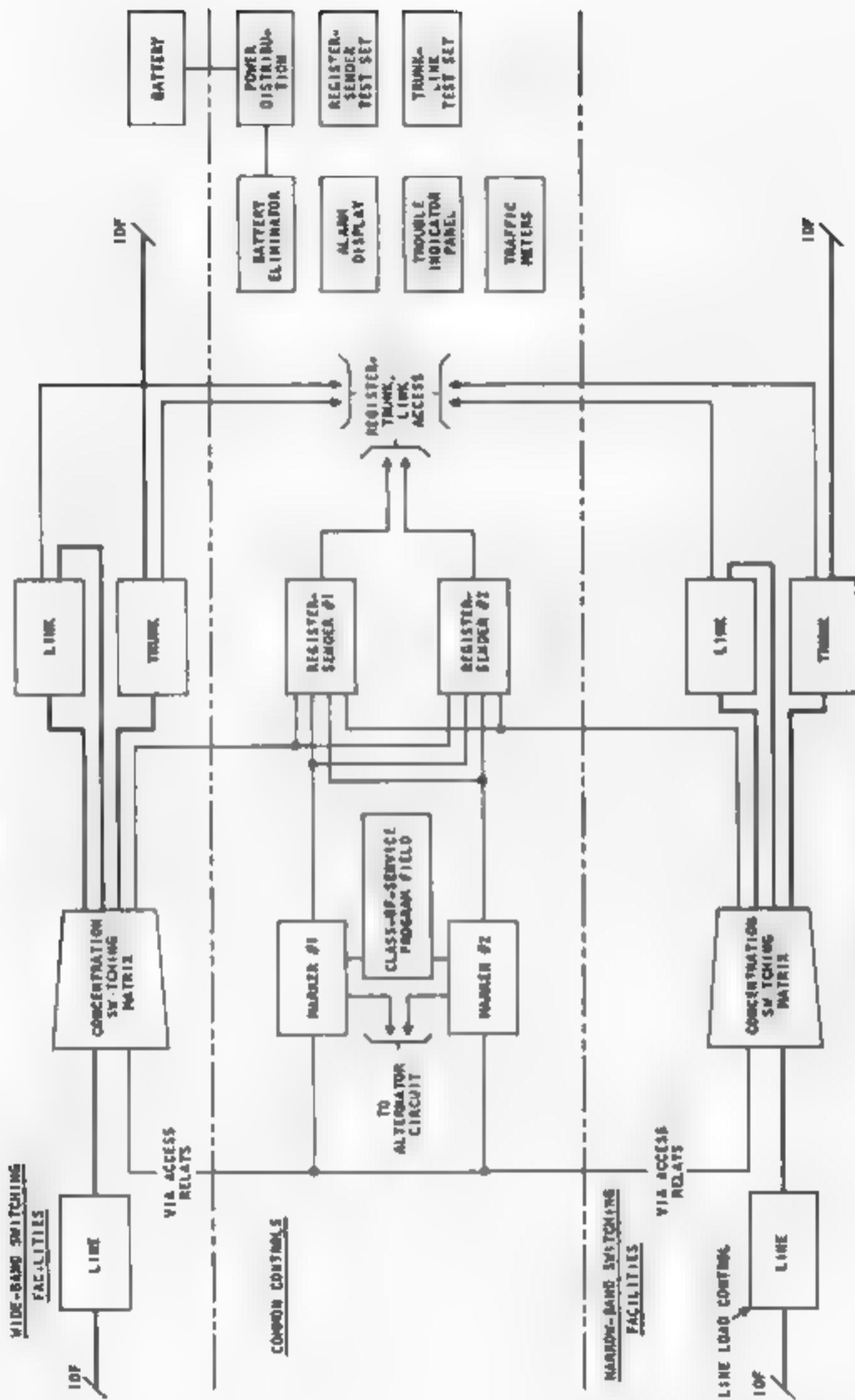


Figure 2. Interconnection of Major Items in a Typical District Office

## Functional Description of Components

### a) Matrix

The switching matrix is a three stage array concentrating 160 inlets (lines) to 45 outlets (trunks, links and registers). The transmission path is a two-wire circuit with additional wires for control and signalling purposes. A matrix module, shown in Figure 3, contains 25 reed relays arranged in a 5 x 5 pattern. These modules are interconnected through wiring on the backplane of the subrack. The quantity and arrangement of these modules and their interconnection in the matrix is determined by the number of subscribers and the amount of traffic.

A path is tested and established through the Primary, Secondary and Tertiary stages of the matrix by the marker.

operate wire. However, if the path is idle, the signal is detected. Thus, by testing all outlets from the appropriate primary switch and all inlets to the appropriate tertiary switch the marker can find a path through the matrix. Application of ground and battery respectively on the Primary and Tertiary stages of the selected path operates the relay cross points of the matrix. This terminal or "end marking" technique combines the selection of an available path with the actual crosspoint "setup" procedure. If the call is blocked due to traffic conditions, alternate paths are tried.

### c) Register/sender

The number of registers at each location depends upon the traffic load. The register sender is a unit of the common

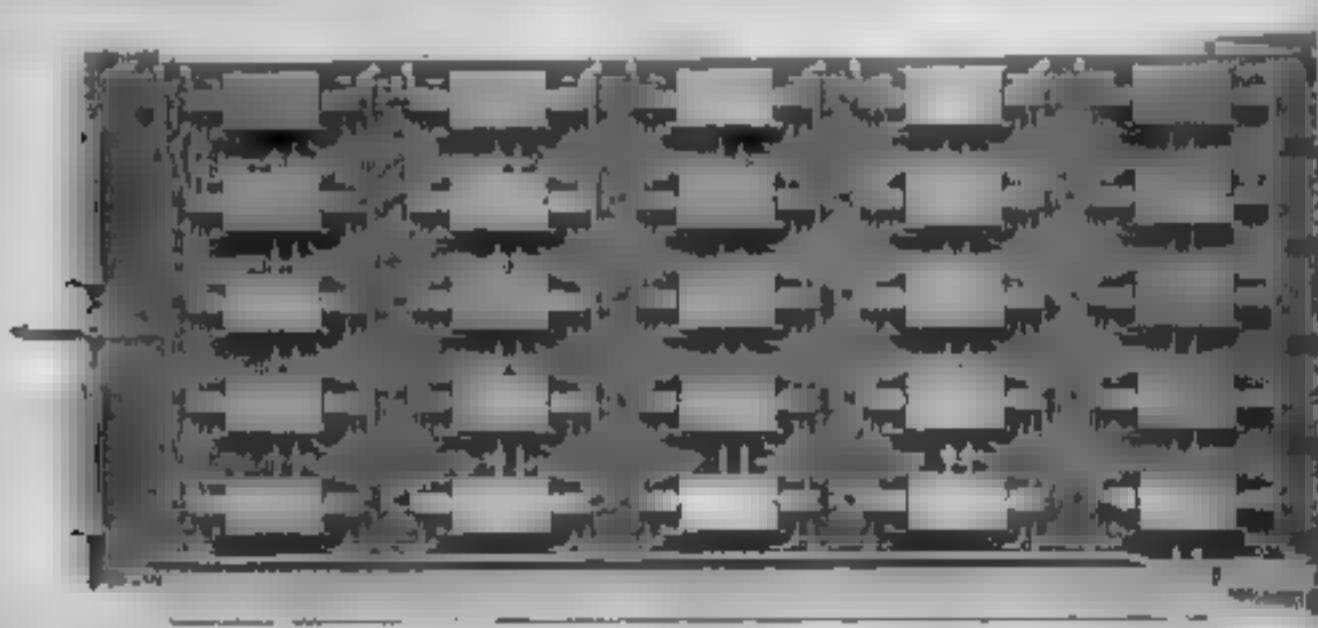


Figure 3. Matrix Module

### b) Marker

Before setting up a connection through the matrix, the marker applies test voltages to the appropriate operate wires on each side of the matrix. There is a high impedance test circuit between the operate and hold wires on each primary-to-secondary connection, and on each secondary-to-tertiary connection. The marker determines the state of the hold wires by means of this test circuit. If a path is in use, the potential on the hold wire prevents detection of the test signal applied to the

control. Its prime function is to accept, check and transmit addressing and status information. This information is normally received in serial form from a line or trunk and is converted to a two-out-of-five parallel error checking code within the register. Retransmission is in serial form. The registers are capable of operating on standard 10 pps dial pulse, as well as 75-, 110- and 150 bauds. Selection of proper mode and speed is done by means of internal diode logic and variable clock rates. The register also verifies, by means of query and

answer back routines, that proper connections have been established, otherwise it transmits distinctive signals indicating fault conditions.

#### d) Trouble Indicator

If a double operation of any circuit element controlling the setup of a connection occurs or if any operation exceeds a pre-determined interval, the trouble indicator is called in to record the fault condition on a display panel. This panel consists of rows of lamps marked with equipment descriptions and/or functions.

A fault will result in the illumination of specific lamps. Analysis of these lamps forms the basis of remedial action by maintenance personnel.

Major and minor trouble conditions which require corrective action are indicated by audible and visual alarms.

#### e) Trunk and Line Circuits

The trunk and line circuits provide the interface between the transmission facilities and the switching equipment. All line and trunk circuits provide two-way operation which permits seizure from either end. Polar 12 volt full duplex signalling is used for both transmission and signaling.

### Maintenance and Monitoring Equipment

In addition to the functional components detailed above, several test devices are provided at each office. These units provide means of testing all routines of the Register-Sender and also the trunks and links. Switches on all functional units permit faulty components to be bypassed and isolated from the operating equipment. Buss-ockout switches and off-line testing features allow the defective section to be tested under operating conditions without interfering with traffic.

In order to provide information regarding traffic patterns, peg count meters are provided on all lines to indicate the total time the particular line is occupied by originating traffic. Additional counters indicate the number of times all registers are busy and all trunks in a group are occupied. Overflow counters are also provided on the trunk groups.

### How a Call is Made

The following description traces the progress of a call through an office.

A positive signal on the send and receive transmission paths of lines and trunks is maintained in the idle condition. An incoming call is indicated by a reversal of battery. The first sequence performed by the marker is to determine whether a line or trunk is calling. The marker then selects an available register and sets it for the baud rate at which the address information will arrive. For example, the marker recognizes an incoming trunk signal and then sets the register to 150 baud. An 8-level ASCII Code subscriber line (operating at 100 WPM) will set the register to receive at 110 baud, whereas a seizure from a line with a BAUDOT or 5 level machine (operating at 100 WPM) will set the register to 75 baud.

The setting of the register to the proper baud rate is based on the marker's analysis of the class of service mark associated with the calling line.

After the register has been attached to the calling line through the 3-stage concentration matrix, the marker places the line's equipment number and class of service in the register's storage.

When the register recognizes that all necessary information has been received it requests the marker's second routine to determine the trunk route required. The marker then examines the information in the register and translates the address into a trunk group and selects an idle trunk within that group. If there are no idle trunks within the group, the marker will make an alternate choice to another office in an attempt to complete the call.

After the route has been selected, the marker directs the matrix to drop the line-to-register connection and sets up a line-to-trunk connection. The register is then connected to the selected trunk via the register-access matrix.

This matrix is a single stage array using dry reed relays similar to those used in the concentration matrix. Each register has access to one side of the matrix and each trunk and link has access to the other side.

The seizure of a trunk results in a reversal of polarity sent to the distant office. In reply, the distant office returns a pulse as an indication that the far end of the trunk has been seized and tested. This provides a check of the transmission facilities. A second pulse is generated by the distant office after a register is attached. The sender section of the calling register-sender is activated after these two revertive pulses are received. The sender then proceeds to forward the 5 digits of the address of the called line and class of service of the calling line in an asynchronous 2-out-of 5 code at a 150 baud rate.

In the terminating District Office a register, which has been attached to the incoming trunk through the register access matrix, receives the address information. When it recognizes that complete information is stored it calls for the marker which then compares the class of service of the terminating line with the class of service received from the incoming trunk. If they are compatible and the line is not busy, the connection is established through the concentration matrix.

Answer supervision is then returned to the originating District Office, where the register-sender sends two WRU control characters to trigger the answer-back of the called teleprinter. When the answer back is received the numerical portion is compared with the digits of the address which remained stored in the register.

The register normally remains attached until receipt of an answer-back, or an OCC (busy) or DER (fault) indication. If the answer-back checks, the register extends the cut-through signal and withdraws. If the answer-back does not check, or if an OCC or DER indication is received, or if the register times-out before receiving a recognizable signal, it withdraws without extending a switch-through signal. In this case, the trunk assumes a busy lock-out condition until both terminals automatically disconnect.

Under normal conditions the trunk circuits hold the matrix connection under the control of the local user. The trunk connections to the intermediate offices are released when the call is completed and the remote user disconnects.

## Outstation Equipment

Most of the outstation teleprinters used in the ARS are Types 33 and 35 ASCII 8 level ASR units.<sup>2,3</sup> These machines and the control characters (X-ON and X-OFF) available in the ASCII code permits almost complete automatic operation of the Advanced Record System.

The standard format for a punched tape message requires that an X-OFF (Transmitter Off) character be punched in the tape immediately following the address digits. Recognition by the teleprinter of this character and the X-ON control character results in semi-automatic transmission from the prepunched tape as follows.

1. The operator places the pre-punched tape containing the address and text in the tape transmitter of the teleprinter.
2. The operator then presses the "Request" button on the teleprinter console. This signals the office to attach a register.
3. When the register is attached it immediately sends out the "X-ON" character which starts the address header of the tape through the transmitter.
4. Recognition by the teleprinter of the X OFF character punched in the tape after the address digits, stops the transmitter.
5. After the answer-back routine generated by the register has confirmed that the proper connection has been established, the register sends a second X-ON character to start the text portion of the tape through the transmitter.
6. At the end of the text, another X-OFF and WRU are read from the tape. The second answer-back query routine is then initiated which reconfirms the connection. The "X off" stops the tape transmitter. Either operator may then disconnect.

In addition to the "X-off" control character in the tape format, operator routine requires the address to be preceded by a lefthand bracket or [. This character is used to unlock the register so no spurious characters will be stored prior to the address. Immediately after the bracket, the 5-digit directory number of the called subscriber is transmitted from the pre-punched tape and stored in the register.

## Special Features

In summary, some of the more outstanding features of the CSN design are:

- Recognition of unique control characters permit messages to be sent and received without full time operator attendance.
- Automatic transmission of address and text is done from pre-punched tape.
- The registers can accept dial-pulse signals as well as ASCII and Baudot codes.
- ASCII and Baudot teleprinters may be intermixed on the DO terminals.
- Cross office set-up time is less than one second.
- Trunk signaling is done at the high rate of 150 baud.
- Alternate routing is provided at the District Office level.
- Expansion can be done on a plug-in basis.

- Compatibility checks of subscriber teleprinter types are provided through flexible "class of service" assignments.
- Glass reed relays are utilized to reduce maintenance.
- The common control portion of an office is used for both narrowband and wide band switching.
- Automatic generation of "Who Are You" characters and verification of proper answer-back eliminate wrong connections.
- Automatic printout of distant-end answer-back confirms proper connections.
- Distinctive printouts indicate Busy or Fault conditions.

\* \* \* \*

## References

1. D. Corruth—Advanced Record System—W.U. Tech. Review Jan. 1966 Vol. 20 No. 1
2. F. Smith—New 8 Level Teleprinters and ASR sets—W.U. Tech. Review April 1965—Vol. 19, No. 2
3. F. Smith—New American Standard Code for Information Interchange—W.U. Tech. Review April 1964—Vol. 18, No. 2

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HOWARD E. BROOKS, CSN Manager in the GSA Program of the Information Systems and Services Department, has been associated with the project since its inception. His prime responsibility has been to coordinate all aspects of the switching system design and implementation. Previously he was associated with the Broadband Switching Group in which his functions included the evaluation of proposals and equipment, as well as acting as liaison between the subcontractor and various departments within Western Union. When he started at Western Union, he was active in the design and testing of several public and leased facsimile systems such as Deskfax, Ticketfax and Letterfax.

Mr. Brooks received his B.S. degree in Electrical Engineering from Columbia University in 1948. He is a member of the Wire Communications Committee of IEEE.



# ***new products planned for western union***

—Warren H. Fisher

A Product Planning and Engineering Operation procedure has recently been inaugurated within the Information Systems and Services Department. This Section, known as Product Planning and Industrial Design, is headed by a Director\* and dedicated to comprehensive product planning, product evaluation and product design, suggested by the marketing and service requirements of the immediate and future Western Union. Its goal is a standard product "line" consistent with the new company image, business intent and economy.

#### **Three sub-sections**

Three sub-sections of this effort, each headed by a cognizant Manager, will operate in the areas of (1) Product Requirements and Planning, (2) Product Evaluation and Information and (3) Industrial Design.

The "Product Requirements and Planning" group will perform analysis and develop product plans within the framework of company wide marketing needs, business intent, availability of required products, establish courses of action and recommendations to satisfy product needs. It will plan commercial and in-house product developments and determine proper quantities of the product line to be warehoused.

The "Product Evaluation and Information" group will direct the formal evaluation of all products recommended for Western Union product line by the Manager of Product Requirements and Planning, to determine whether or not they are reliable, maintainable, easily operable and appropriate for the proposed service application. This group will also be the source for product information throughout the Company and will provide guidance in the proper use of available products. A Product Line Catalog, Technical Reference Manuals and periodic Product Information Reports will be a continuing "output" of this group.

The Industrial Design group will provide a company-wide design service functioning as a joint effort with engineering personnel, to design and produce a contemporary product line. Such a Product Line will contribute to the Western Union corporate image, and be more competitive in today's market. From a broad viewpoint, Industrial Design is concerned with the external product configuration and Human Factors engineering, but additional areas of contributions are: (1) basic packaging (2) visual quality of materials, finishes and controls, (3) Product identification and graphics.

This newly formed Section will therefore, provide a consistent, standard and harmonious Product Line which will enhance Western Union's position in a competitive market.

\* The Director, W. M. Fisher, is responsible to the Assistant Vice President, R. H. McConnell. Mr. Fisher is Chairman of the Committee on Technical Publications.

# *industrial design*

*at*

## *western union*

—David H. Dabney

Industrial Design, as a profession, has recently gained momentum, although it has been a profession for 35 to 40 years. It grew from the conviction that the appearance of a product is important to the consumer and can influence its position in a competitive market. Careful study of many factors relative to eye appeal, resulted in a design philosophy that has proved its value. Increased consumer acceptance of those products to which it was applied confirmed its significance. In the present state of the art other aspects such as Human Factors Engineering are considered. This discipline deals with the operation of the product relative to the people who use it. This machine/operator interface involves many physical considerations such as manual controls, access and maintenance in addition to visual displays such as dials, and signal lights.

### **Objective**

A basic design objective for developing a contemporary product is simplicity of form. This simplicity is the result of the organization, and unification of basic

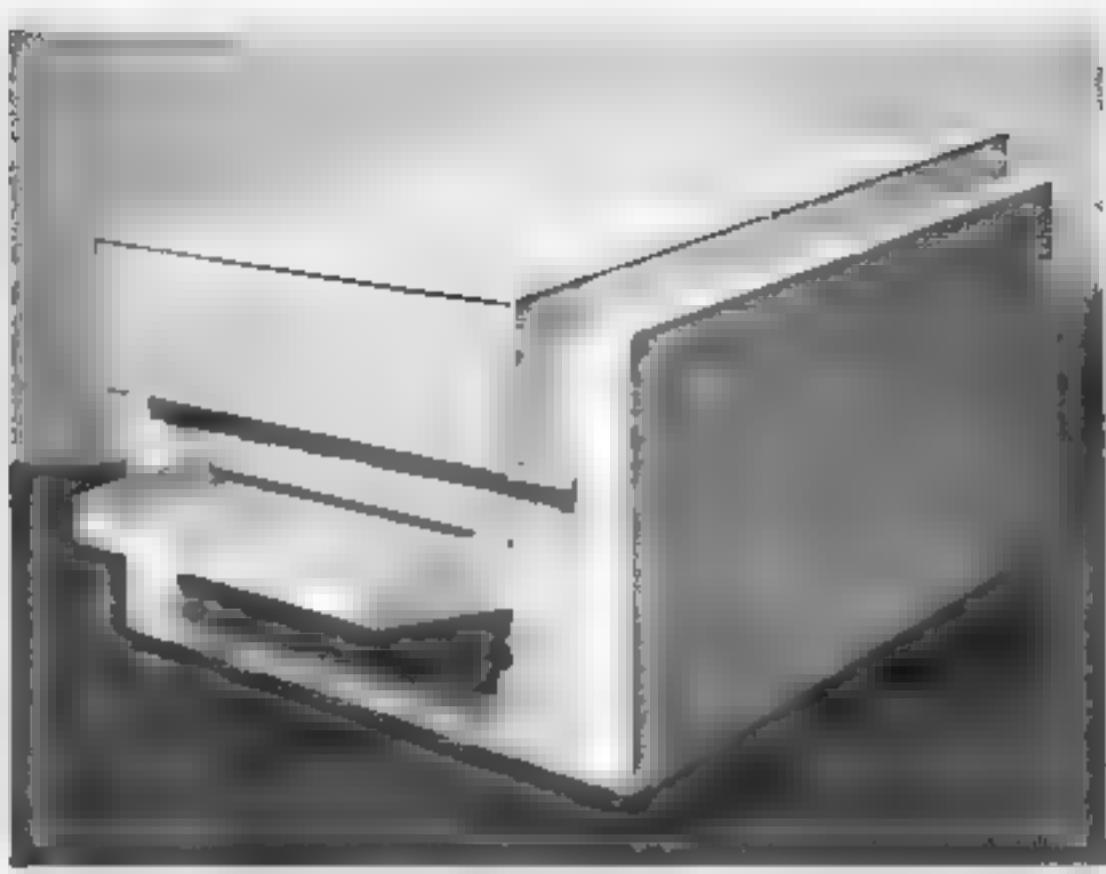
shapes and the elimination of unnecessary forms and details

### **Cost**

Industrial Design properly applied, should not add to the cost of a product beyond its contribution. However, a certain percentage of the product cost should be allotted to expressing the functional excellence and quality as well as the basic packaging. An expensive machine should reflect the cost and be handled differently from a product of lesser value. Obviously there is more money to allot to design in the more expensive unit. Quality, to some degree, is also controlled by different production methods. The choice of the kind of production to be used, to produce a product, is in turn dependent upon the nature of the product, the service it performs and the quantity to be produced.

A low quantity production seldom justifies injection molding of plastics or die casting because the large die costs can not be amortized over short runs. However, these methods give higher quality at less unit cost

**Figure 2.**  
**Cardboard**  
**Mock-up**  
**of**  
**Facsimile**  
**Transceiver**



### **Engineer/Designer Team**

The Engineer and the Industrial Designer function as a team, each dependent upon the knowledge and experience of the other to jointly design a product which will have acceptance from a functional and visual standpoint. It will express the quality and the function for which it was designed and will compete with others in the market.

The Industrial Design function begins with the designer entering the project at an early stage. This enables him to gain a broader insight into the problem. The external configuration of a product is, of course, a result of the location of the internal elements. However, these elements may sometimes be repositioned, within a workable framework, and thus offer alternate engineering approaches which contribute to a better product, both functionally and visually.

When the preliminary sketches and exploded views are produced by the Industrial Designer, they aid the engineer in visualizing ideas, analyzing problems and to assist him in selling ideas to management. As the project progresses these sketches are revised to keep them up-to-date and to allow comparison of the various approaches.

### **Product Planning**

The Industrial Designer can contribute to product planning and engineering in two ways. (1) By designing new products from the conception stage and (2) by designing new enclosures to modernize old but functionally adequate products. Occasionally three dimensional models, constructed of clay or cardboard, aid the engineer in giving him a preview of the shape and functional aspects of a product long before a prototype can be constructed. The cardboard model can be made for a fraction of the cost of other types of models. They may be finished, if desired, with all controls and nameplates. Fig. 1 is a model or cardboard mock up of a Facsimile Transceiver now being developed for Western Union. This model is a result of a program initiated by the Product Planning and Engineering Operation in conjunction with the manufacturer. The external configuration was developed around a basic engineering concept but these external aspects as well as the implementation of the basic idea have undergone many modifications during the course of development. The model has helped to determine solutions to problems such as visual access, access for maintenance, cover design, display of controls, trademarking and identification.



Figure 2. Operating Table #11481 (Early Design)

Industrial Design can also be implemented in upgrading equipment that is functionally adequate but visually outdated. The 11481 Operating Table, the Telex version of the 19 Set, shown in Fig. 2, is an example of a good product for which a face-lift would update its appearance and perhaps add years to its use. This unit, when designed some 20 odd years ago, was assembled from several existing units combined to perform a function. Because it has become visually outdated by today's design

standards, the continued use of this equipment becomes increasingly difficult. An additional factor of customer rejection, is the difficulty in keeping the unit clean. The wrinkle finish and the hard-to-get-at crevices collect dust. The appearance is further aggravated by the fact that four or five elements are assembled on a table and not integrated into a single product. This product, when used in the customer's office, suffers by comparison with contemporary office equipment.

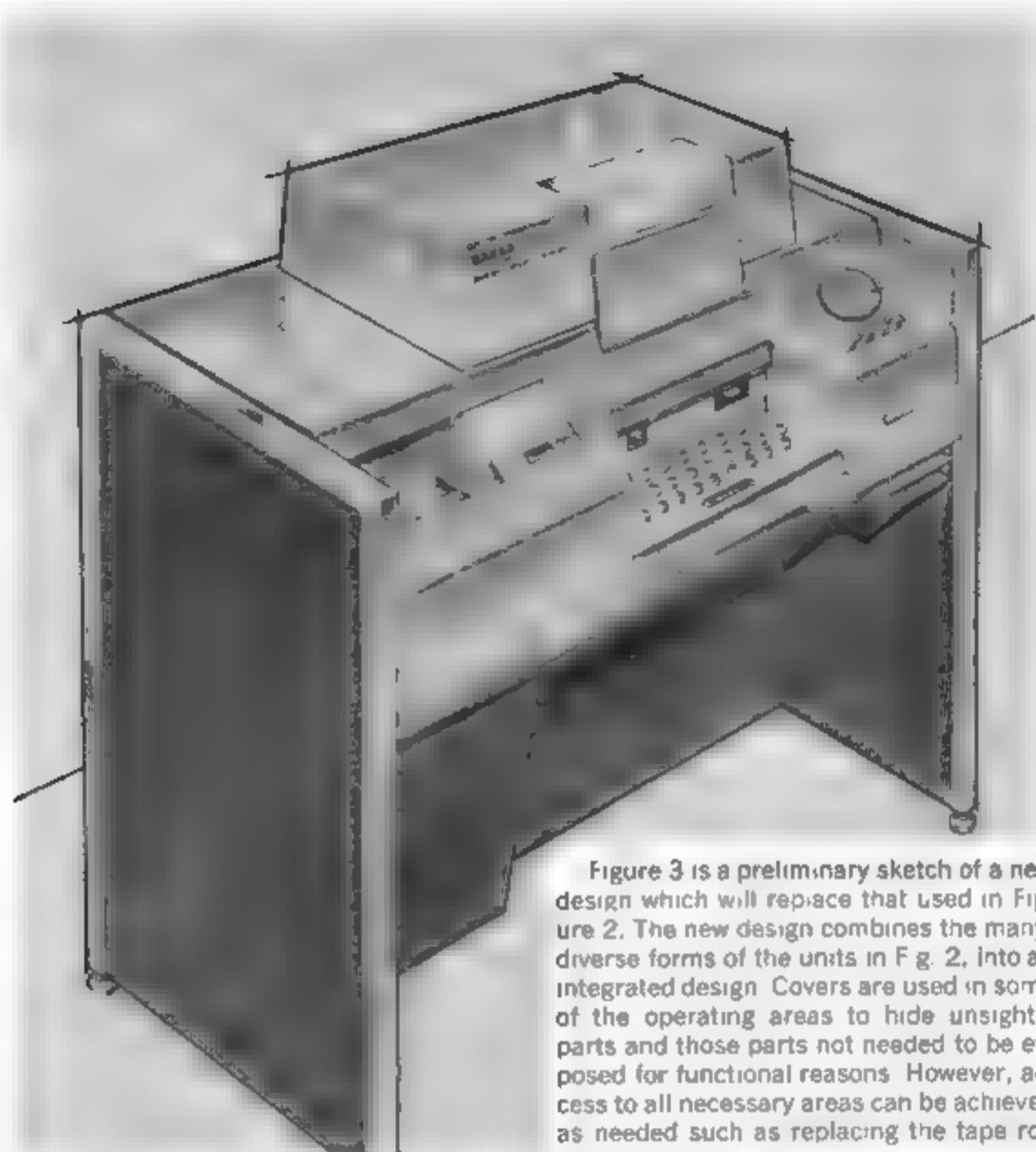


Figure 3. Operating Table #11481  
(New Design)

Figure 3 is a preliminary sketch of a new design which will replace that used in Figure 2. The new design combines the many, diverse forms of the units in Fig. 2, into an integrated design. Covers are used in some of the operating areas to hide unsightly parts and those parts not needed to be exposed for functional reasons. However, access to all necessary areas can be achieved as needed such as replacing the tape roll or servicing.

DAVID H. DABNEY, Manager of the Industrial Design, in the Information Systems and Services Department, is responsible for the new product image being developed to go with the new Western Union trademark or logo.

He received his B.S. degree in Industrial Design from the University of Cincinnati in 1951. He was in the consulting field of Industrial Design for over 10 years, and an Account Executive with Raymond Loewy Associates for over 6 years.

He joined the Western Union Telegraph Co. in 1965 after working with the General Electric X-Ray Co. as Senior Industrial Designer in Charge of Medical X-Ray equipment.



*information explosion  
discussed  
at the  
ieee*

The Impact of Information Explosion on Communications for Government and Industry was the subject of a panel discussion at the IEEE International Convention March 23, 1966 at the New York Hilton Hotel in New York City. Mr. Robert L. Francisco, Assistant Vice President and Manager, Management Information Systems in the Information Systems and Services Dept. discussed the Information Utility. The objective of the panel discussion was to provide a broad based look at current and future roles of data communication technology as well as to explore applications and trends from the user, planner, regulator and supplier points of view.

As supplier, Mr. Francisco said,



Do you remember when we thought the computer could give us all the answers?

All you had to do was to ask the questions

Such as

'Where is the information to come from?'

"How can I get my hands on it?"

'And how fast?'

'And how much?'

For many questions, computers are not the complete answer

Because geography enters in—Government and industry are spread out—So, you need something else—You need communications . . . . .

. . . The impact of the information explosion can finally be resolved by communications. . . .

. . . How do we determine what communications are going to be needed in any given system? . . . . . First, you have to determine your information needs . . . . Only 10% of the computers installed today are being fully utilized and contributing to the information needs of the user. Why? The majority didn't have a visionary overview of corporate needs in our expanding economy. But now users and technical systems people do recognize and corporate management is beginning to become aware of the broader scope of the impact of information on its business, and in particular, the timeliness of that information.

This raises the question of what information should be processed and where to achieve the objective at minimum cost. With communications as an element in the system, you now have the flexibility of choice. You can evaluate the merits of a completely centralized information system in which all remote corporate users are connected to a single processing center and share use of the central computer complex. Conversely, a number of lesser processing centers can be arranged to serve sub-groups in a corporation. In this case, the need arises to determine and provide for the transfer of common data between these processing centers and to a corporate headquarters to satisfy the requirements of centralized control.



R. L. Francisco, Asst. V P  
and Manager of  
Information Systems  
and Services in  
the I. S. & S. Dept.  
discusses the  
Information Explosion  
at the I. E. E. Convention

This introduces a balancing act involving:

- Computer size
- Computer cost
- Program compatibility
- Off-line v. on-line processing
- Shared systems
- Common language
- Types of displays
- Common data banks
- Computers of same or different manufacturers
- Division of processing between machines

and the proper role of real-time in all these applications

This information systems designer's new dimension is communications. The best balance of all of these factors lies in an optimum choice of communications.

Three things come into play in this optimization—

1. The speed at which you wish to communicate (75 bauds or 48,000 bauds)
2. The distance you must communicate between
3. The time it will take to communicate

All these have a bearing on the system economics and must be considered against your information needs. . . .

. . . So, where does this bring us? Finally, it brings us to the rise of a new industry entirely—what I choose to call: The Computility! An information utility that can make information available—as someone has said—"at the push of a button and at the speed of light."

And what will this information utility do? It will gather, store, process, program, retrieve, and distribute on the broadest scale possible virtually all of the collected, useful intelligence needed to operate a business. . . .

. . . I believe, we can and are learning—at Western Union—about what it takes to build a "Computility."

#### Editorial Note:

The discussion period which followed revealed many questions from the audience regarding the regulation of data-communication services and its effect on the Information Utility

We are beginning with message switching. But our plans go way beyond this as you will see.

In some ways, the need for an information utility is growing—like Topsy . . . . We are fond of thinking of it in terms similar to that of an electric utility . . . . where the service used will be metered . . . . and bills rendered on the basis of these meter readings. Where the only capital investment will be for the data equipment you elect to own or furnish (much as you now provide your own electric appliances for your home or office).

But, perhaps, it will not grow this way. Perhaps it will be closer to the growth of a transportation system . . . . where there are a great number of private users—with machines of their own—like the automobile. And a number of dedicated systems—like taxis. And a number of shared systems—like buses. The development of the industry is unknown at present and largely unknowable. Because so much depends on things like "regulation"—and "standardization".

But, this much we do know. . . . There is a need for information both raw processed and finished. These are the services that should be provided by a common carrier. But this can only happen if the same foresight with which the Communications Act of 1934 was drafted is applied. That act enhanced the possibility of message interchange . . . . Regulation must be designed to continue to enhance not just message interchange, but information exchange. We as a carrier are confident that this will come about. We as a carrier are preparing to furnish that service. . . .

. . . By 1970 anyone . . . . whether in need of data processing—or information—or just communications—will be able to plug into the first feasible information utility in history, The Computility

# *patents recently allowed*

## **Storage Network Comprising a Neon Tube**

R. STEENECK

3,227,956—JANUARY 4, 1966

This invention relates to a memory storage device which employs glow discharge type of devices as storage media. Such a device is a neon tube which is connected to a resistive network having input, output and reset terminals. Some advantages afforded by this type of storage system are that it provides a visual indication of data stored, it can be reset to its original state easily and is economical to build. Operation of this storage circuit is quite simple in that it requires an input potential signifying data to be stored which is of such a value as to make the neon lamp assume a conductive state. On the other hand, the lamp is placed in a non-conductive state by a suitable potential which is applied to the reset terminal.

## **Electrically Inscribable Lithographic Offset Printing Plate**

B. L. KLINE, D. P. RODDIN

3,220,345—NOVEMBER 30, 1965

An electrically inscribable offset printing plate comprising a non-conductive base sheet with a layer of conductive carbon homogeneously dispersed in a resinous or elastometric binder thereon and coated with an adherent electrosensitive facsimile substance to mask the underlying black colored conductive layer. This offset printing plate which is about 3½ mils thick can obtain high ink receptivity of the recorded subject matter while allowing the carbon layer to have good conducting characteristics whereby excellent

definition may be obtained during a recording operation. This inexpensive printing plate can record pictorial subject matter with suitable gradation in tone and permit a multiple of copies to be obtained by offset printing methods.

## **Frequency Shift Signaling System**

H. C. LIKEL

3,205,441—SEPTEMBER 7, 1965

This invention provides a simplified transmission system with continuous, coherent keyed signals and means for translating the frequency of a frequency shift keying modulated wave downward by frequency division or for translating the frequency of such a wave downward by a combination of frequency division and heterodyning. Formerly frequency shift of a carrier was obtained by altering the parameters and constants of an oscillator tank circuit in response to a keying signal or by using separate oscillators operated at different frequencies. The disadvantages of such practices were the variation in the parameters of the tank circuit due to changes in temperature and the discontinuous output resulting from use of separate oscillators. The present invention eliminates these disadvantages by utilizing a single frequency source in conjunction with binary divider chains to provide an output wave that is continuous, coherent and having all the characteristics of a frequency modulated wave of an ideal frequency shift keying system. This results in the minimizing of keying losses on shifting from one frequency to another and at the same time provides a system that is relatively simple to service.

Probability

Error Detection  
Computer Techniques  
Computer-Switching Systems  
Reliability

Rider, Bernard: Reliability in Communications Systems  
Western Union TECHNICAL REVIEW, Vol. 20, No. 2 (April 1966)  
pp. 50-54

This article examines reliability in computer-controlled message switching systems and suggests that special consideration be given to the employment of redundancy for high reliability.

Data Transmission  
Data Processing  
Electro-Mechanical Devices  
Transmitters

Feld, Newton: New Punched Card Transmitter for Data Communications Systems—Part III—Operation  
Western Union TECHNICAL REVIEW, Vol. 20, No. 2 (April 1966)  
pp. 56-61

The last of three articles on the New Punched Card Transmitter, this article outlines the theory of operation of the mechanisms and the electronic logic used in the transmitter. Part III describes the card feed, the read head, the indexing wheel—and the electronic timing logic and their related operation as components of the Punched Card Transmitter.

Network  
Data Processing  
Advanced Record System  
Circuit Switching

Brooks, Howard E.: Circuit Switching Network for Advanced Record System  
Western Union TECHNICAL REVIEW, Vol. 20, No. 2 (April 1966)  
pp. 70-76

The Circuit Switching Network is the heart of the Advanced Record System designed for GSA. This article outlines the operation of District Offices. It gives the functions of matrix, marker, register, trouble indicator and circuits.

Data Processing  
Modernization  
Repeaters

Likel, Harry C.: A Transistorized Data Network Repeater  
Western Union TECHNICAL REVIEW, Vol. 20, No. 2 (April 1966)  
pp. 62-69

This article describes the operation of the transistorized data network repeater with consideration given to the anti-home record copy circuit, lock out circuit, open circuit blind, anti-break-in circuit, break-in alarm, open line blind circuit and the regenerative repeater. This repeater will likely replace the relay type repeater now in service.

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**Production Standardization**

Fisher, Warren H.: **New Products Planned for Western Union**  
Western Union TECHNICAL REVIEW, Vol. 20, No. 2 (April 1966)  
p. 77

A new Product Planning and Engineering Operation has been established in the Information Systems and Services Department. This article defines the responsibilities of the three sub-sections in this group: (1) Product Requirements and Planning, (2) Product Evaluation and Information, and (3) Industrial Design.

**Modernization Production Terminal Equipment**

Dabney, D. H.: **Industrial Design at Western Union**  
Western Union TECHNICAL REVIEW, Vol. 20, No. 2 (April 1966)  
pp. 78-81  
p. 77

Industrial Design properly applied, should not add to the cost of a product to any excessive degree. This article describes Western Union's team effort in more effectively designing new products—and in updating the appearance of old equipment.

**PWS Systems Engineering Announcements Information Explosion**

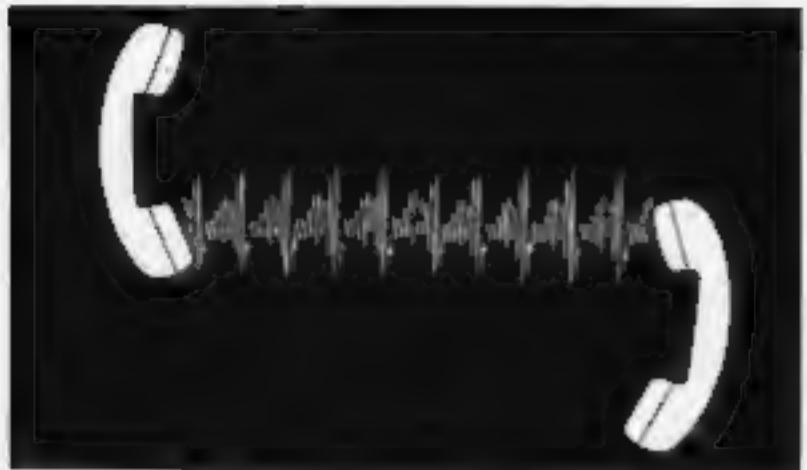
Information Explosion discussed at the IEEE  
Western Union TECHNICAL REVIEW, Vol. 20, No. 2 (April 1966)  
pp. 82-84  
p. 77

Excerpts from the speech on the Information Utility, given by Mr. Robert L. Francisco, Assistant Vice President and Manager—Management Information Systems in the I.S.&S. Dept. at the International Convention of the IEEE held in New York City on March 23, 1966.

**PWS Announcements Hot/Line**

Western Union's Hot/Line Service Expansion, Vol. 20 No. 2 (April 1966)  
p. 88  
p. 77

Scheduled to be available in late 1966, Western Union's Hot/Line service provides a private service of voice-grade trunk circuits, connecting two points or cities. This service makes it impossible for a subscriber to encounter a busy condition, unless the whole trunk is busy.



## ***western union's hot/line service expansion***

*The Special Projects Operation of the Information Systems and Service Department is planning to expand Hot/Line Systems during the latter part of 1966. These installations will include systems from such major cities as New York to Chicago, Los Angeles, San Francisco and Washington, D.C.*

*The Hot/Line Telephone service is a private service, whereby a group of Western Union subscribers utilize a dedicated common pool of voice-grade trunk circuits, connecting two points or cities. The subscriber's access is limited from his station to a specific station location in another city.*

*A call is initiated by simply placing the telephone instrument in an "off-hook" position. Normally, a trunk is available and a direct connection will be made resulting in a telephone ring at the remote station. If the originator encounters a busy trunk, a "Camp On" signal will be generated signifying that the phone should be returned to the "on-hook" position. As soon as a trunk becomes available, the originator will automatically be called—indicating that the through connection or trunk is ready for use. The private line service makes it impossible to encounter a busy condition, from other than an all trunk busy situation. Furthermore, an "exclusion feature" allows for private conversation by excluding extensions on location, if desired.*

*As an additional feature, facsimile equipment transmission is being planned as an alternate mode for interested subscribers.*